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By Commander Henry Glass, U. S. N.

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Dyer, N. M.	Commander
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Elmer, H.	Commander
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Fernald, F. L.	Naval Constructor
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Fiske, B. A.	Lieutenant
Fitts, J. H.	Asst. Engineer
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Folger, W. M.	Commander

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Ford, W. G., Esq.	New York
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Fullam, W. F.	Ensign
Galt, R. W.	P. Asst. Engineer
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Garrett, L. M.	Ensign
Garvin, J.	Lieutenant
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Glennon, J. H.	Ensign
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Gorgas, A. C.	Medical Director
Gorgas, M. C.	Ensign
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Grant, A. W.	Ensign
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Greene, F. E.	Lieutenant
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Hannum, W. G.	Ensign
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Hemphill, J. N.	Lieutenant
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Nicoll, W. L. P. Asst. Engineer
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Peck, R. G. Lieutenant
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Remey, E. W.	Lieutenant
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Robie, E. D.	Chief-Engineer
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Rodgers, C. R. P.	Rear-Admiral
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Russell, J. H.	Commodore
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Sampson, W. T.	Commander
Sargent, N.	Lieutenant
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Schouler, J.	Lieut.-Commander
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Sebree, U.	Lieutenant
Selfridge, J. R.	Lieutenant
Selfridge, T. O.	Captain
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Semple, L.	Ensign
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Sharrer, W. O.	Lieutenant
Shaw, C. P.	Lieutenant
Shepard, E. M.	Commander
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Stevens, T. H.	Lieutenant
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Sturdy, E. W.	Lieutenant
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Talcott, C. G.	Asst. Engineer
Taussig, E. D.	Lieutenant
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Tilton, McL.	Capt. U. S. M. C.
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Train, C. J.	Lieut.-Commander
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Turner, T. J.	Medical Director
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Underwood, E. B.	Lieutenant
Upshur, J. H.	Rear-Admiral
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Warburton, E. T.	Asst. Engineer
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Washington, R.	Pay Inspector
Watson, E. W.	Lieut.-Commander
Weaver, W. D.	Asst. Engineer
Webb, T. E.	Naval Constructor
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Wilson, J. C.	Lieutenant
Wilson, T. D.	Chief-Constructor
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Wood, W. M.	Lieutenant
Woodbridge, W. E., Esq.	Washington
Woodward, J. J.,	Asst. Naval Const'r
Woodworth, S. E.	Ensign
Woolverton, T.	Surgeon
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Worden, J. L.	Rear-Admiral
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Yates, I. I., Esq.	Schenectady
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Zane, A. V.	P. Asst. Engineer

LIFE MEMBERS—48.

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Belknap, C.,	Lieutenant.	Prize Essayist, 1880.
Very, E. W.,	Lieutenant.	Prize Essayist, 1881.
Kelley, J. D. J.,	Lieutenant.	Prize Essayist, 1882.
Calkins, C. G.,	Lieutenant.	Prize Essayist, 1883.
Chambers, W. I.,	Ensign.	Prize Essayist, 1884.

Allen, R. W.	Paymaster
Barker, A. S.	Commander
Bixby, W. H.	Captain U. S. A.
Brown, Austin P., Esq.,	Washington, D. C.
Brush, G. R.	Surgeon
Center, Robert, Esq.	New York
Coryell, M., Esq.	New York
Dayton, J. H.	Lieutenant
Delamater, C. H., Esq.	New York
Evans, E. T., Esq.	Buffalo
Fletcher, A., Esq.	New York
Forbes, R. B., Hon.	Milton, Mass.
Gardner, H. W., Esq.	Providence
Gorringe, H. H., Esq.	Philadelphia
Hanford, F.	Lieutenant
Hicks, B. D.	Old Westbury, N. Y.
Hunsicker, J. L.	Lieutenant
Keim, G. De B., Esq.	Philadelphia
Kirby, Frank E., Esq.	Detroit, Mich.
Leary, J. D., Esq.	Brooklyn
Mason, T. B. M.	Lieutenant
Merrell, John P.	Lieutenant
Moore, J. H.	Lieutenant
Palmer, N. F., Jr., Esq.	New York
Perkins, G. H.	Captain
Phœnix, Lloyd, Esq.	New York
Pond, C. F.	Ensign
Quintard, G. W., Esq.	New York
Reamey, L. L.	Lieutenant
Roach, John, Esq.	Chester, Pa.
Rowland, T. F., Esq.	Brooklyn
Schroeder, S.	Lieutenant
Slack, W. H., Esq.	Washington
Smith, J. A.	Paymaster General
Steers, H., Esq.	New York
Tanner, Z. L.	Lieut.-Commander
Thomas, C. M.	Lieut.-Commander
Thurston, R. H., Prof.	Hoboken, N.J.
Ubsdell, J. A., Esq.	Port Eads, La.
Ward, Aaron,	Lieutenant
Watrous, Chas., Esq.	New York
Weed, G. E., Esq.,	New York

HONORARY MEMBERS—9.

Arranged in order of Election.

Hon. W. E. Chandler (ex-officio).
Chief-Justice C. P. Daly.
President C. W. Elliott, LL. D.
Captain J. Ericsson.
General U. S. Grant.
Professor J. E. Hilgard.
John D. Jones, Esq.
Lieutenant Alfred Collett.
President D. C. Gilman, LL. D.

ASSOCIATE MEMBERS—107.

Abbot, F. V.	1st Lieut. U. S. A.
Acland, W. A. D.	Commander R. N.
Angstrom, A.	C. E. Torpedo Stat'n
Barr, F.	Capt. U. S. R. M.
Batten, A. W. C.	Lieutenant R. N.
Bessels, E., M. D.	Washington
Bogert, J. L., Esq.	Flushing, N. Y.
Bole, J. K., Esq.	Cleveland, O.
Boutelle, C. O.	Capt. Assistant C. S.
Brooke, J. M.	Prof. Lexington, Va.

Cahill, John, Esq. Baltimore
Campbell, J. B. Captain U. S. A.
Chase, Constantine, 1st Lt. U. S. A.
Chase, Leslie, Esq. New York
Colwell, A. W., Esq. New York
Comly, Clifton, Major U. S. A.
Copeland, C. W., Esq. New York
Davenport, R. W., Esq. Germantown, Pa
Davis, D. P., Esq. New York
Davies, Dayrell, Lieut. R. N.
Dobson, W. A., Esq. Bu. C. and R.
Drake, M. M., Esq. Buffalo, N. Y.
Dufferin, Henry J., M. E., Bk'ln, N. Y.
Durfee, W. E., M. E. Bridgeport, C.
Emery, C. E., Esq. New York
Eckel, Herman, Esq. Cincinnati, O.
Falsen, C. M. Lieut. Norwegian N.
Faron, E., Esq. Orange, N. J.
Forster, E. J., M. D. Boston
Gatling, Dr. R. J. Hartford, Conn.
Gibbons, Chas., Jr., Esq. Phila.
Gilpin, F. M., Esq. Phila.
Grant, J. J., Esq. Flushing, N. Y.
Greenough, G. G. Capt. U. S. A.
Grice, F. E., Esq. Bu. C. and R.
Halsey, James T., Esq. Rich. Va.
Hand, S. Ashton, Esq. Toughkenamon, Penn.
Handbury, T. H. Major U. S. A.
Hillman, G., Esq. City Island, N. Y.
Hills, Henry S., Esq. Cincinnati, O.
Hoffman, J. W., Esq. Philadelphia
Humphrey, E. W. C. Louisville
Hunt, W. P., Esq. Boston
Keckeler, A. T., M. D. Cincinnati
Kent, Wm., Esq. New York
Laureau, L. G., Esq. New York
Le Baron, J. F., Asst. Eng. U. S. A.
Lieb, Chas. A., Esq. New York
Lyon, Henry, M. D. Boston
MacMurray, J. W. Major U. S. A.
Maguire, E. Captain U. S. A.
Mann, H. F., Esq. Pittsburg, Pa.
Manton, J. P., Esq. Providence
Martinez, M. J., Esq. New York
Marx, J. L. Lieutenant R. N.
Mensing, A. Capt. Imp. G. Navy
Miller, H. W., Esq. Morristown, N. J.
Miller, P. P., Esq. Buffalo
Millis, John, 1st Lieutenant U. S. A.
Moore, Chas. A., Esq. New York
Mullett, A. B., Esq. Washington
Myers, T. B., Esq. New York
Nordhoff, C., Esq. Alpine, N. J.
Oliver, W. L., Esq. San Francisco
Owens, F. D., Esq. Washington, D.C.
Partridge, W. E., M. E., Williamsburgh, N. Y.
Payson, A. H. Captain U. S. A.
Peck, R. H., Esq. New York
Pennypacker, J. W., Esq. Phœnixville, Pa.
Pollock, A., Esq. Washington, D. C.
Powell, W. T., Esq. Bu. C. and R.
Pratt, N. W., Esq. New York
Reilly, H. J. 1st Lieut. U. S. A.
Reynolds, G. H., Esq. New York
Roepper, C. W., Esq. Alliance, O.
Ropes, J. C., Esq. Boston
Russell, A. H. 1st Lieut. U. S. A.
Saito, M. Lieut. Japanese Navy
Sargent, C. S. Prof. Harvard Univ.
Schneider, Henri, Esq. The Creusot, France
Scudder, E. M., Esq. New York
Sears, W. H., Esq. Boston, Mass.
See, Horace, Esq. Philadelphia
Shaw, A. J., Esq. Stamford, Conn.
Simpson, J. M. Capt. Chilian Navy
Sinclair, Angus, Esq. New York
Sloat, Geo. V., Esq. New York
Smedburg, W. R., Lieut. Col. U. S. A.
Stetson, Geo. R., Esq. New Bedford, Mass.
Stratton, E. P., Esq. New York
Stueler, R., Esq. New York
Taber, H. S. Captain U. S. A.
Towne, Henry R., Esq. Stamford, Conn.
Turtle, T. Captain U. S. A.

Tillman, S. E., Prof. West Point
Vanderbilt, A., Esq. New York
Vesselago, T. T. Lieut.-Genl. Russian Navy
Webber, W.O., Esq. Lawrence, Mass.
Wellman, S. T., Esq. Cleveland, O.
West, Thos. D., Esq. Cleveland, O.
Wheeler, F. M., Esq. New York
White, J. F., S. B. Torpedo Station
Wisser, J. P. 1st Lieut. U. S. A.
Willamov, G. Con. Gen. Russia, N.Y.
Wilson, A. E. Lieut. Chilian Navy
Woodall, W. E., Esq. Baltimore
Zalinski, E. L. 1st Lieut. U. S. A.

CORRESPONDING SOCIETIES.

United States.

American Academy of Arts and Sciences, Boston, Mass.
American Chemical Journal, Baltimore, Md.
American Geographical Society, New York City.
American Institute of Mining Engineers, New York City.
American Iron and Steel Association, Philadelphia, Pa.
American Metrological Society, Columbia School of Mines, New York City.
American Philosophical Society, Philadelphia, Pa.
American Society of Civil Engineers, New York City.
American Society of Mechanical Engineers, New York City.
Connecticut Academy of Arts and Sciences, New Haven, Conn.
Franklin Institute, Philadelphia, Pa.
Geographical Society of the Pacific, San Francisco.
Military Service Institution of the U. S., Governor's Island, N. Y.
Ohio Mechanics Institute, Cincinnati, O.
School of Mines Quarterly, New York City.

Foreign.

Association Parisienne des Propriétaires d'Appareils à Vapeur, Paris.
Giornale d'Artiglieria e Genio, Rome.
Hydrographisches Amt der Kaiserlichen Marine, Berlin.
Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.
Institution of Civil Engineers, London.
Institution of Mechanical Engineers, London.
Mittheilungen a. d. Gebiete d. Seewesens, Pola.
Norsk Tidsskrift for Sovæsen, Horten, Norway.
Reunion des Officiers de Terre et de Mer, Paris.
Revue Maritime et Coloniale, Paris.
Rivista Marittima, Rome.
Royal Artillery Institution, Woolwich.
Royal United Service Institution, London.
Société des Ingénieurs Civils, Paris.

NECROLOGY.

LIEUTENANT JOHN P. J. AUGUR. Born March 31, 1852. Appointed a Cadet Midshipman, September 26, 1866. Graduated, June 7, 1870. Served on board the Brooklyn and Plymouth, European Squadron, from July, 1870, to June, 1873. Commissioned an Ensign, July 13, 1871. Served on board Powhatan, North Atlantic Squadron, from September, 1873, to October, 1874. Commissioned a Master, July 22, 1874. Served on board Kearsarge and Tennessee, Asiatic Squadron, from April, 1875, to July, 1878. Ordered to Nautical Almanac Office, September, 1878. Ordered to Alliance, North Atlantic Squadron, December 19, 1879. Commissioned a Lieutenant, January 4, 1881. Detached from Alliance on May 12, 1883. Ordered to receiving ship Colorado, September 17, 1883, and on October 23 was detached and placed on waiting orders. December 8, 1883, was granted one year's sick leave. He died at New York on January 9, 1884. Sea service, ten years and ten months. Shore duty, four years and one month. Total service, seventeen years and three months.

ENSIGN FRANK WELCH BOWDON. Born January 16, 1858. Appointed a Cadet Midshipman, September 24, 1875. Graduated, June 3, 1880. Ordered to the Galena, August 13, 1880, and detached June 1, 1882. Appointed a Midshipman, June 22, 1882. Ordered to training ship New Hampshire, August 18, 1882, and on October 4 was detached and ordered to special duty in Bureau of Navigation. Commissioned an Ensign, Junior Grade, March 3, 1883. Ordered, September 1, 1883, to Trenton. He died on board the Trenton, at Korea, on June 24, 1884. Total sea service, two years, eleven months. Shore duty, five years and four months. Total service, eight years and nine months.

EDWARD A. FIELD was appointed a Midshipman in the Navy, July 22, 1865. June 9, 1869, was detached from the Naval Academy and ordered to the Sabine, 30th instant. July 28, 1870, was detached and ordered to examination for promotion, 30th instant. October 28, 1870, promoted to Ensign, from July 12, 1870; was ordered the same day to Torpedo duty. April 3, 1871, detached and ordered to the Shawmut, 10th instant. August 27, 1872, detached and ordered to Torpedo duty, September 2. September 6, 1872, previous orders revoked and ordered to examination for promotion. September 12, 1872, commissioned as Master, from December 26, 1871. October 5, 1872, ordered to the Frolic. February 11, 1873, detached and ordered to the Guard, 28th instant. March 8, 1873, detached (sick) and granted three months leave. July 1, 1873, ordered to the Frolic. October 21, 1873, detached and ordered to the Kearsarge, per steamer of November 5. August 24, 1876, detached and placed on sick leave. February 6, 1877, commissioned as Lieutenant, from February 10, 1875. March 1, 1877, ordered to the receiving ship Wabash. February 13, 1878, detached and granted one month's leave. March 9, 1878, ordered to the Constellation. July 24, 1878, detached and placed on waiting orders. August 10, 1878, ordered to the receiving ship Wabash. January 25, 1879, detached and ordered to the Marion, February 5. September 17, 1879, detached and ordered to the Wachusett. July 28th, 1881, returned home sick. October 29, 1881, ordered to the receiving ship Passaic. March 30, 1882, detached and ordered to the Hydrographic Office. June 27, 1882, detached and placed on waiting orders. July 25, 1882, ordered to the Montauk. December 5, 1882, detached and placed on waiting orders. December 20, 1882, ordered to the Swatara. January 14, 1884, detached from the Swatara and ordered to his home. He died at Boston, Mass., on December 27, 1884.

COMMODORE THOMAS SCOTT FILLEBROWN. Born in District of Columbia, August 13, 1824. Appointed a Midshipman in the Navy, October 19, 1841. Attached to Frigate Congress, Mediterranean Squadron, 1842–1845. Steam Frigate Mississippi, Home Squadron, 1846–1847. Naval School, 1847. Promoted to Passed Midshipman, August 10, 1847. Frigate St. Lawrence, Mediterranean Squadron, 1849–1851. Naval Observatory, 1851. Store Ship Lexington, Pacific Squadron, 1851–1852. Sloop Vincennes, North Pacific Expedition, 1852–1856. Promoted to Master, 1855. Commissioned as Lieutenant,

September 15, 1855. Naval Observatory, 1857–1858. Steamer Release, Paraguay Expedition, 1858–1859. Commanding Steamer Anacostia, 1859–1860. Steam Frigate Roanoke, 1861. Commissioned as Lieutenant-Commander, July 16, 1862. Navy Yard, New York, 1862–1863. Commanded Gunboat Chenango, 1863. Commanded Ironclad Passaic operating against Fort Sumpter during May, 1864. Commanded Steamer Sonoma, South Atlantic Blockading Squadron, 1864–1865. Naval Observatory, 1866. Commissioned as Commander, July 25, 1866. Hydrographic Office, 1867–1868. Commanded Steam Sloop Narragansett, 1869. Special duty, Washington, 1869–1870. Bureau of Equipment and Recruiting, 1871–1872. Commanded Shenandoah, European Squadron, 1873. Commissioned as Captain, January 6, 1874. Navy Yard, Norfolk, 1874–1876. Commanded Powhatan, North Atlantic Squadron, 1877–1879. Special duty, Navy Department, 1880–1882. Commissioned as Commodore, May 7, 1883. Ordered to command Navy Yard, New York, March 31, 1884. Died at Navy Yard, New York, September 26, 1884. Sea service, twenty-three years, one month. Shore duty, seventeen years, four months. Total service, forty-two years, eleven months.

Samuel Dana Greene was appointed an Acting Midshipman in the Navy, September 21, 1855. Graduated June 9th, 1859. Was warranted as Midshipman from June 9, 1859, and ordered to the Hartford the same day. September 18, 1861, was commissioned as Lieutenant, from August 31, 1861. December 5, 1861, was detached from the Hartford and granted two weeks leave. January 23, 1862, was ordered to the Monitor—Executive officer of the Monitor during the action with the rebel Merrimac at Hampton Roads and vicinity, March 9, 1862. On the Monitor during engagemeut at Sewell's Point, May 9 or 10, 1862—also in the fight at Fort Darling, James River, May 15, 1862. January 5, 1863, ordered to the Florida. September 25, 1863, detached and placed on waiting orders. October 31, 1863, ordered to special duty at New York. February 10, 1864, detached and ordered to the Iroquois. October 3, 1865, detached and placed on waiting orders. October 7, 1865, promoted to Lieutenant Commander, from August 11, 1865. October 17, 1865, ordered to the Naval Academy. September 30th, 1868, detached and ordered to the Ossipee. April 21, 1870, detached from the

Saranac, and ordered to command the. Saginaw. January 19, 1871, detached and ordered to command the Nyack. May 23, 1871, detached from the Pacific Fleet and ordered to the Naval Academy, 1st May. December 12, 1872, promoted to the grade of Commander. December 10, 1874, detached from the Naval Academy and ordered to command the Juniata. September 7, 1876, detached and ordered to command the Monongahela. July 24, 1877, detached and placed on waiting orders. September 15th, 1877, ordered to the Naval Academy. April 1, 1882, detached and placed on waiting orders. April 10, 1882, ordered to special duty, Washington, D. C. July 1, 1882, detached and ordered to command the Despatch, 15th inst. April 23, 1884, detached and ordered to the Navy Yard, Portsmouth, N. H. He died at the Navy Yard, Portsmouth, N. H., on the 11th December, 1884.

HENRY O. HANDY was appointed an Acting Midshipman in the Navy, July 25, 1865. Graduated at the Naval Academy, July 4, 1869. June 30, 1869, ordered to the Sabine. July 28, 1870, detached and ordered to examination for promotion, 30th September. October 28, 1870, promoted to Ensign, from July 12, 1870. October 28, 1870, ordered to the Navy Yard, Boston. November 30, 1870, detached and ordered to the California, 10th December. September 30, 1873, detached from the Narragansett and placed on waiting orders. November 18, 1873, commissioned as Master, from July 12, 1871. January 14th, 1874, ordered to the Frolic. March 30, 1874, detached and granted three months' leave of absence. July 15, 1874, ordered to duty on the Coast Survey. January 22, 1875, commissioned as Lieutenant, from November 9, 1874. December 31, 1875, detached from duty on the Coast Survey, and ordered to the Vandalia, 10th January. January 20, 1879, detached and placed on waiting orders. June 2, 1879, ordered to Torpedo instruction. September 6, 1879, detached and placed on waiting orders. January 9, 1880, ordered to the receiving ship Wabash. October 20, 1881, detached and ordered to the Brooklyn, 2d November. October 15th, 1884, detached and placed on waiting orders. December 8, 1884, granted six months' leave of absence. He died at Washington, North Carolina, on the 23d December, 1884.

REAR ADMIRAL ANDREW ALLEN HARWOOD. Born October 9, 1802. Appointed a Midshipman in the Navy, January 1, 1818.

Served on board the Brig Saranac, 1818, and Sloop-of-war Hornet, 1819-1821. Navy Yard, Philadelphia, 1822. Steamer Sea Gull, 1823. Frigate Constitution, 1824-1827. Commissioned as a Lieutenant, March 3, 1827. Receiving ship Philadelphia, 1828-1830. Navy Yard, New York, 1831-1832. Frigate United States, Mediterranean Squadron, 1832-1833. Frigate Potomac, Schooner Shark and Frigate Constitution, Mediterranean Squadron, 1835-1837. New York Station, on special service, 1840-1843. Assistant Inspector of Ordnance, 1843-1852. In 1884 he was a member of a Commission to visit dockyards and foundries in England and France and to report on Ordnance improvements. Commissioned as Commander, October 2, 1848. Commanded Frigate Cumberland, Mediterranean Squadron, 1853-1855. Commissioned as Captain, September 14, 1855. Inspector of Ordnance, 1858-1861. Commissioned as Chief of Bureau of Ordnance and Hydrography, August 6, 1861. Commissioned Commodore, July 16, 1862. Commandant Navy Yard, Washington, and of the Potomac Flotilla, 1862-1863. Secretary Light-House Board, 1864-1869. Placed on Retired List, October 9, 1864. Commissioned as Rear Admiral, February 16, 1869. Member of Retiring Board, 1869-1872. Died August 28, 1884. Sea service, fourteen years, three months. Shore duty, twenty-seven years, four months. Total service, sixty-six years, eight months.

BENJAMIN F. RINEHART was appointed a Cadet Midshipman in the Navy, September 26, 1868, and graduated at the Naval Academy, June 1, 1872. August 1, 1872, he was ordered to the Yantic; was transferred to the Hartford and detached from that vessel October 16, 1875, and ordered to examination for promotion. November 18, 1875, was commissioned as an Ensign, from July 15, 1875. November 18, 1875, ordered to the Powhatan. December 17, 1875, detached and ordered to the Supply; and on the 14 September, 1876, he was detached and placed on waiting orders. February 13, 1877, ordered to the Omaha, per steamer of 28th inst. and remained attached to that vessel until April 27, 1878, when he was detached and placed on waiting orders. June 15, 1878, was commissioned as a Master, from December 1, 1877. October 17, 1878, ordered to the Pensacola. May 13, 1880, detached 2d inst., and ordered to the Receiving Ship Independence. July 28, 1880, detached and ordered to the Lackawanna. April 3, 1882, detached and placed on waiting orders. June

29, 1882, ordered to the Hydrographic Office. June 1, 1883, Commissioned as Lieutenant (Junior Grade), from March 3, 1883. July 21, 1883, detached from the Hydrographic Office, and placed on waiting orders. May 16, 1884, was ordered to the Naval Hospital, New York, for treatment. November 8, 1884, was ordered to examination for promotion. November 14, 1884, previous order revoked, and case referred to the Retiring Board. November 26, 1884, he was placed on the Retired List. He died at Waynesburg, Pennsylvania, on the 29th December, 1884.

CONSTITUTION AND BY-LAWS.

ARTICLE I.—Title.

This organization shall be called the United States Naval Institute.

ARTICLE II.—Object.

Its object is the advancement of professional, literary, and scientific knowledge in the Navy.

ARTICLE III.—Headquarters.

The Headquarters of the Institute shall be at the United States Naval Academy, Annapolis, Md.

ARTICLE IV.—Officers.

The officers shall be as follows:

A President.

A Vice-President.

A Board of Control.

A Secretary and Treasurer.

A President and Corresponding Secretary for each Branch.

ARTICLE V.—Election of Officers.

Sec. 1. There shall be a meeting of the Institute at Headquarters on the second Friday in October of each year, of which at least two weeks notice shall be given, at which meeting all the foregoing officers, except those of Branches, shall be elected by ballot in open session, and a majority of votes given by presence or proxy shall elect; regular or life members only being eligible for office.

Sec. 2. Absent members who have the constitutional right to vote may vote by proxy at such elections, and in the same manner on all questions involving changes in the Constitution and By-Laws, and upon questions involving the expulsion of members and the election of honorary members. On all other questions voting must be by actual presence. Life members shall have the full right of regular members to vote on every question. Honorary and associate

members shall not have the privilege of voting. All proxies must be signed by the member whose vote is to be represented.

SEC. 3. Members elected to the position of officers of the Institute will assume their respective duties at the date from which elected.

SEC. 4. Casual vacancies in the officers of the Institute may be temporarily filled by the Board of Control.

ARTICLE VI.—DUTIES OF OFFICERS.

SEC. 1. The President shall preside at business meetings of the Institute, or its branches, at which he may be present.

SEC. 2. In the absence of the President at Headquarters, the Vice-President shall preside.

SEC. 3. The Board of Control shall consist of seven members in good standing, regular or life, and its duties shall be the management of all the financial and administrative business of the Institute, including the censorship, printing, and control of its publications. The Secretary and Treasurer shall be, *ex officio*, a member of the Board, its medium of communication and the recorder of its transactions. The regular meetings of the Board of Control shall be held upon the first and third Saturday of each month. A special meeting shall be called by the Secretary and Treasurer upon the written application of two members of the Board. A quorum shall consist of three members. In the absence of both the President and Vice-President at business meetings of the Institute, a member of the Board of Control shall preside. It shall be the duty of this Board to appoint a committee of three of its own members to audit and certify the books and accounts of the Secretary and Treasurer at least once every quarter.

SEC. 4. The Secretary and Treasurer shall keep a register of the members in which shall be noted all changes; an authenticated copy of the Constitution and By-Laws in force; a journal of the Proceedings of the Institute; a separate journal of the transactions of the Board of Control; a receipt and expenditure book; an account-current with each member. Under the authority of the Board of Control, he shall be the disbursing and purchasing officer of the Institute and the custodian of the funds, securities, and assets, and it shall be his duty to furnish members with receipts for dues paid. He shall attend to all correspondence and keep a record thereof, give due notice of meetings of the Institute and Board of Control, have charge of the stenographer and copyists employed to prepare records of the

proceedings, and he shall distribute all publications. The books of account of the Institute shall always be open to inspection by any member. Papers accepted by the Board of Control shall be read by the Secretary and Treasurer when the author cannot be present.

ARTICLE VII.—Membership.

Sec. 1. The Institute shall consist of regular, life, honorary, and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fees to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

Sec. 5. Associate members shall be elected from officers of the Army, Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next

meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing.

SEC. 8. The annual dues for regular and associate members shall be three dollars, payable upon joining the Institute, and upon the first day of each succeeding January. The fee for life membership shall be thirty dollars, but if any regular or associate member has paid his dues for the year in which he wishes to be transferred to life membership, or has paid his dues for any future year or years, the amount so paid shall be deducted from the fee for life membership.

SEC. 9. No member of the Institute shall be dismissed except by recommendation of the Board of Control, and by a two-thirds vote of the members of the Institute voting at any regular or called meeting, of which, at least, one month's notice shall be given. Without the recommendation of the Board of Control, no member can be dismissed except by a three-fourths vote. In both the above cases there must be a total vote of at least a majority of all those members entitled to a vote, the voting to be either by presence or proxy. Members two years in arrears shall be dropped. Those dropped for non-payment of dues can regain their membership by paying two years arrearage of dues, but the Board of Control may adjust any special case upon its merits.

ARTICLE VIII.—RESERVE FUND.

The amount now invested ($1800) in United States and District of Columbia bonds shall be placed to the credit of a Reserve Fund. All moneys received from life membership fees shall, as soon as practicable, be invested in United States bonds, or bonds guaranteed by the United States, and shall be added to said fund, which shall be held in perpetuity to guarantee the future interest of said life members. The interest of said fund may, however, be used for the current expenses of the Institute.

ARTICLE IX.—MEETINGS.

SEC. 1. The regular time of holding meetings of the Institute shall be the second Friday of each month, but if there should be no paper accepted by the Board of Control to be read, professional subject to be discussed, or executive business to be transacted, the monthly meeting may be omitted.

SEC. 2. Special meetings of the Institute shall be called by the Secretary and Treasurer when directed by the Board of Control.

SEC. 3. Notice of regular or special meetings shall state the title of papers to be read, with the name of the author, and mention the executive business that will be brought before the meeting.

SEC. 4. A stenographer may be employed when authorized by the Board of Control.

ARTICLE X.—PAPERS AND PROCEEDINGS.

SEC. 1. Quarterly, or as much oftener as the Board of Control may decide, the papers read before the Institute and its Branches, together with the discussions growing out of them, shall be published. Papers on intricate technical subjects of such a character as not to be appreciated on merely casual investigation, and articles too extended to be read at one meeting of the Institute, may be published as a part of the Proceedings when authorized by the Board of Control; and there may also be published, under the heads of Editorial and Professional Notes, such comment and information as may be deemed of value to the service.

SEC. 2. One copy of the Proceedings, when published, shall be furnished to each regular, life, honorary, and associate member, to each Corresponding Society of the Institute, and to such libraries and periodicals as may be determined upon by the Board of Control.

SEC. 3 Copies of the Proceedings and complete sets may be sold at a charge fixed by the Board of Control, and the Board shall also fix the price of annual subscription for others than members.

SEC. 4. A receipt and expenditure account of the Institute's publications, showing the number on hand, shall be included in the report of the Secretary and Treasurer of each year.

SEC. 5. The Board of Control shall decide the size of the edition of each number of the Proceedings to be published, and also the number of reprints.

ARTICLE XI.—ANNUAL PRIZE ESSAY.

SEC. 1. A prize of at least one hundred dollars, with a gold medal, shall be offered each year for the best essay on any subject selected by the Board of Control.

SEC. 2. The award for the above-named prize shall be made by a board of three competent and disinterested judges appointed by the Board of Control, and the time and manner of submitting such essays shall be determined and announced by said Board.

SEC. 3. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

ARTICLE XII.—BRANCHES.

SEC. 1. The Board of Control is empowered to appoint Corresponding Secretaries for all Naval Stations, both ashore and afloat, where there is no organized Branch; also for Branches where a vacancy exists owing to the resignation of the Corresponding Secretary before a meeting can be called to elect a successor.

SEC. 2. The officers of a Branch shall be a Vice-President and a Corresponding Secretary.

SEC. 3. The Vice-President shall perform the same duty for the Branch as prescribed for the President of the Institute.

SEC. 4. The Corresponding Secretary of a Branch shall keep a register of the members residing within the limits of the Station, and an account-current with each. He shall keep a journal of the proceedings of the Branch and a copy of the Constitution and By-Laws. He shall give due notice of all meetings of the Branch, and shall have control of the stenographer whenever it is deemed necessary to employ one. He shall forward to the Secretary and Treasurer of the Institute all papers read before his Branch, and keep him informed of all new members and their addresses, and of all business relating to the Institute. He shall have charge of the Branch library and of all books and papers, and shall receive and distribute publications. He shall keep a receipt and expenditure book, shall collect dues from members on the Station and give receipts therefor. He shall be authorized to expend such part of the funds in his possession for stationery, postage, printing, and for other incidental expenses as may be deemed necessary. He shall at the end of each month render to the Secretary and Treasurer a detailed statement of moneys received and expended, with vouchers for expenditures, and shall forward to the Secretary and Treasurer the funds remaining on hand, retaining only sufficient to defray the estimated current expenses of the Branch for the ensuing month.

SEC. 5. Monthly meetings of each Branch may be held upon such dates as the Branch shall decide, but if there is no paper to be read or business to be transacted at the appointed date, the Corresponding Secretary may omit the call for the regular meeting. Special meetings may be called when necessary.

ARTICLE XIII.—Copyright.

The Proceedings shall be copyrighted in behalf of the Institute by the Secretary and Treasurer.

ARTICLE XIV.—Amendments.

No addition or amendment to the Constitution shall be made without the assent of two-thirds of the members voting; the By-Laws, however, may be amended by a majority vote. Notice of proposed changes or additions shall be given by the Secretary and Treasurer at least one month before action is taken upon them. A total vote equal to at least half the number of regular and life members shall be required.

BY-LAWS.

ARTICLE I.

The rules of the United States House of Representatives shall, in so far as applicable, govern the parliamentary proceedings of the Society.

ARTICLE II.

1. At both regular and stated meetings the routine of business shall be as follows:

2. At executive meetings, the President, or, in his absence, the Vice-President, or, in the absence of both, a member of the Board of Control, shall call the meeting to order, and occupy the chair during the session; in the absence of these, the meeting shall appoint a Chairman.

3. At meetings for the presentation of papers and discussion, the Society shall be called to order as above provided, and a Chairman shall be appointed by the presiding officer, reference being had to the subject about to be discussed, and an expert in the specialty to which it relates being selected.

4. At regular meetings, after the presentation of the paper of the evening, or on the termination of the arguments made by members appointed to, or voluntarily appearing to enter into formal discussion, the Chairman shall make such review of the paper as he may deem proper. Informal discussion shall then be in order, each speaker being allowed not exceeding ten minutes in the aggregate, unless by

special consent of the Society. The author of the paper shall, in conclusion, be allowed such time in making a resumé of the discussion as he may deem necessary. The discussion ended, the Chairman shall close the proceedings with such remarks as he may be pleased to offer.

5. At the close of the concluding remarks of the Chairman, the Society shall go into executive session, as hereinbefore provided, for the transaction of business as follows:

1. Stated business, if there shall be any to be considered.
2. Unfinished business taken up.
3. Reports of Officers and Committees.
4. Applications for membership reported and voted upon.
5. Correspondence read.
6. Miscellaneous business transacted.
7. New business introduced.
8. Adjournment.

NAVAL INSTITUTE PRIZE ESSAYS, 1879-1885.

1879.

Subject:—"NAVAL EDUCATION.—I. OFFICERS. II. MEN."

Judges of Award:—CHARLES W. ELIOT, President of Harvard University; DANIEL AMMEN, Rear-Admiral, U. S. N.; WM. H. SHOCK, Engineer-in-chief, U. S. N.

Winner of the Prize:—Lieutenant-Commander ALLAN D. BROWN, U. S. N. *Motto of Essay*:—"Qui non proficit."

First Honorable Mention:—Lieutenant-Commander CASPAR F. GOODRICH, U. S. N. *Motto of Essay*:—"Esse quam videri."

Second Honorable Mention:—Commander ALFRED T. MAHAN, U. S. N. *Motto of Essay*:—"Essayons."

Number of Essays presented for competition, ten.

1880.

Subject:—"THE NAVAL POLICY OF THE UNITED STATES."

Judges of Award:—Hon. WM. M. EVARTS, Secretary of State; Hon. R. W. THOMPSON, Secretary of the Navy; Hon. J. R. MCPHERSON, U. S. Senator.

Winner of the Prize:—Lieutenant CHARLES BELKNAP, U. S. N. *Motto of Essay*:—"Sat cito, si sat bene."

Number of Essays presented for competition, eight.

1881.

Subject:—"THE TYPE OF (I) ARMORED VESSEL (II) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES."

Judges of Award:—Commodore W. N. JEFFERS, U. S. N.; Chief Engineer J. W. KING, U. S. N.; Chief Constructor JOHN LENTHALL, U. S. N.

Winner of the Prize by decision of two of the Judges:—Lieutenant EDWARD W. VERY, U. S. N. *Motto of Essay*:—"Aut Cæsar, aut nullus."

Recommended for the Prize by one of the Judges:—Lieutenant SEATON SCHROEDER, U. S. N. *Motto of Essay*:—"In via virtute via nulla."

Number of Essays presented for competition, four.

1882.

Subject:—"OUR MERCHANT MARINE; THE CAUSES OF ITS DECLINE AND THE MEANS TO BE TAKEN FOR ITS REVIVAL."

Judges of Award:—Hon. HAMILTON FISH, Ex-Secretary of State; JOHN D. JONES, President Atlantic Mutual Insurance Company, New York; A. A. LOWE, Ex-President New York Chamber of Commerce.

Winner of the Prize:—Lieutenant JAMES D. J. KELLEY, U. S. N. *Motto of Essay:*—"Nil clarius aquis."

First Honorable Mention:—Master CARLOS G. CALKINS, U. S. N. *Motto of Essay:*—"Mais il faut cultiver notre jardin."

Second Honorable Mention:—Lieutenant-Commander F. E. CHADWICK, U. S. N. *Motto of Essay:*—"Spero meliora."

Third Honorable Mention:—Lieutenant RICHARD WAINWRIGHT, U. S. N. *Motto of Essay:*—"Causa latet: vis est notissima."

Essay printed by request of John D. Jones, Esq.—Ensign W. G. DAVID, U. S. N. *Motto of Essay:*—"Tempori parendum."

Number of Essays presented for competition, eleven.

1883.

Subject:—"HOW MAY THE SPHERE OF USEFULNESS OF NAVAL OFFICERS BE EXTENDED IN TIME OF PEACE WITH ADVANTAGE TO THE COUNTRY AND THE NAVAL SERVICE?"

Judges of Award:—Hon. ALEXANDER H. RICE; Judge JOSIAH G. ABBOTT; Rear-Admiral GEORGE H. PREBLE, U. S. N.

Winner of the Prize:—Lieutenant CARLOS G. CALKINS, U. S. N. *Motto of Essay:*—"Pour encourager les autres."

First Honorable Mention:—Commander N. H. FARQUHAR, U. S. N. *Motto of Essay:*—"Semper paratus."

Second Honorable Mention:—Captain A. P. COOKE, U. S. N. *Motto of Essay:*—"Cuilibet in arte suâ credendum est."

Number of Essays presented for competition, four.

1884.

Subject:—"THE BEST METHOD FOR THE RECONSTRUCTION AND INCREASE OF THE NAVY."

Judges of Award:—Rear-Admiral C. R. P. RODGERS, U. S. N.; D. C. GILMAN, LL. D., President of the Johns Hopkins University; Hon. J. R. HAWLEY, U. S. Senator.

Winner of the Prize:—Ensign W. I. CHAMBERS, U. S. N. *Motto of Essay:*—"Thou too, sail on, O Ship of State!"

Number of Essays presented for competition, two.

1885.

Subject:—"INDUCEMENTS FOR RETAINING TRAINED SEAMEN IN THE NAVY AND THE BEST SYSTEM OF REWARDS FOR LONG AND FAITHFUL SERVICE."

Judges of Award:—Rear-Admiral THORNTON A. JENKINS, U. S. N.; Commander W. S. SCHLEY, U. S. N., Chief of Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.; and Captain JOHN CODMAN, of New York City.

Number of Essays presented for competition, three.

PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE,

ANNAPOLIS, MD.

Organized October 9th, 1873, at the U. S. Naval Academy.

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VOLUME V, No. 2—(Continued.)

VOLUME V, No. 3. WHOLE No. 8. 1879.

VOLUME V, No. 4. WHOLE No. 9. 1879.

VOLUME V, No. 5. WHOLE No. 10. 1879.

VOLUME V, No. 2—(Continued.)

VOLUME VI, No. 1. WHOLE No. 11. 1880.

VOLUME VI, No. 2. WHOLE No. 12. 1880.

VOLUME VI, No. 3. WHOLE No. 13. 1880.

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VOLUME VII, No. 3. WHOLE No. 17. 1881.

VOLUME VII, No. 4. WHOLE No. 18. 1881.

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VOLUME VIII, No. 1—(Continued.)

VOLUME VIII, No. 2. WHOLE No. 20. 1882.

VOLUME VIII, No. 2—(Continued.)

VOLUME VIII, No. 3. WHOLE No. 21. 1882.

VOLUME VIII, No. 4. WHOLE No. 22. 1882.

VOLUME VIII, No. 4—(Continued.)

VOLUME IX, No. 1. Whole No. 23. 1883.

VOLUME IX, No. 2. Whole No. 24. 1883.

VOLUME IX, No. 2—(Continued.)

APPENDIX.

VOLUME X, No. 1. Whole No. 28. 1884.

VOLUME X, No. 2. Whole No. 29. 1884.

VOLUME X, No. 3. Whole No. 30. 1884.

VOLUME X, No. 4. Whole No. 31. 1884.

The Establishment of Steel Gun-Factories in the United States.
By Lieutenant W. H. Jaques, U. S. N.

ANNUAL REPORT OF THE SECRETARY AND TREASURER.

TO THE PRESIDENT, OFFICERS AND MEMBERS OF THE UNITED STATES NAVAL INSTITUTE:

Gentlemen:—The undersigned submits the following report of the interests of the Naval Institute for the year 1884.

The cash statement is as follows:

RECEIPTS.

Balance on hand January 1, 1884, as per last yearly report,		$ 507 53
From dues,		1782 73
From sales of publications,		3530 15
From subscriptions,		566 55
From binding,		226 20
From sales of electrotypes,		40 00
From fees of eleven new life members,		330 00
From sales of medals to former Prize Essayists,		54 50
From interest on $800 in 4 per cent. U. S. Bonds, and $1000 in D. C. 3.65 Bonds,		68 50
Total,		$7106 16

EXPENDITURES.

For postage, freight, expressage, telegraphing, and other incidental expenses at headquarters,	$ 240 49	
For stationery for use at headquarters,	29 23	
For expenses of Branches,	65 68	
For printing publications,	4846 53	
For engraving and lithographing for same,	970 06	
For purchase of six gold medals with die for same,	211 00	
For purchase of back publications,	31 38	
For prize essay 1884,	100 00	
For advertising No. 31,	20 00	
For copyright fee for four numbers,	4 00	
For pay of clerk and messenger at headquarters,	160 00	
		6678 37
Balance on hand January 1, 1885,		$ 427 79

The arrearages for yearly dues of members are, for 1883, $76.50; for 1884, $485.98.

The Institute has on hand back publications as follows:

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 1	211	...	No. 17	none.	...
" 2	263	...	" 18	103	...
" 3	83	...	" 19	131	...
" 4	176	...	" 20	150	...
" 5	144	...	" 21	250	...
" 6	23	...	" 22	295	...
" 7	29	...	" 23	215	...
" 8	55	...	" 24	222	...
" 9	60	...	" 25	1105	51
" 10	16	...	" 26	240	79
" 11	238	...	" 27	323	28
" 12	73	...	" 28	none.	...
" 13	14	...	" 29	235	27
" 14	12	...	" 30	280	15
" 15	3	...	" 31	1001	165
" 16	243	...			

Also 50 volumes of various numbers bound in half-turkey, and 1170 reprints from the separate papers of the Institute's publications.

The net increase in membership during the year 1885 has been as follows:

Regular members,	17
Associate members,	48
Life members, including prize essayist for 1884,	12
Total,	77

And the total membership of the Institute, therefore, now stands as follows:

Regular members,	600
Associate members,	106
Life members,	48
Honorary members,	9
Total,	763

During the year 1884, 16 regular members have resigned, and 8 have died, and 2 associate members have resigned; and these changes have been allowed for in the above statement.

The present individual subscription list, outside of Government subscriptions, amounts to 43. Showing a gain during 1884 of 9.

To our list of Corresponding Societies two have been added during the year.

The patrons of the Institute can be assured as to its past and present success. Its future is not likely to be less, and will be as much more, as they, co-operating with its managers, desire to make it.

ROBERT W. ALLEN,
Secretary and Treasurer.

WASHINGTON, *March* 28, 1884.

TO LIEUT.-COMMANDER THOMAS, U. S. N.,

Secretary.

The undersigned having been requested to determine which of the Essays submitted to them is most worthy of the prize offered by the United States Naval Institute, under conditions which have already been made public, respectfully report that two Essays were entered in competition for the prize. The committee are unanimously of the opinion that the superior of these is that which is signed by a motto beginning "Thou too, sail on, O Ship of State!" and they recommend that the premium be awarded to its author. As the subject of the Essay, "The Reconstruction and Increase of the Navy," is of general interest and of great importance, the committee do not wish to be considered as expressing their concurrence or their non-concurrence in the views which the essayist has presented.

JOS. R. HAWLEY,
C. R. P. RODGERS,
DANIEL C. GILMAN.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XI., No. 1. 1885. Whole No. 32.

NAVAL INSTITUTE, ANNAPOLIS, MD.

APRIL 3, 1884.

COMMANDER CHARLES D. SIGSBEE, U. S. N., in the Chair.

PRIZE ESSAY, 1884.

THE RECONSTRUCTION AND INCREASE OF THE NAVY.

By ENSIGN W. I. CHAMBERS, U. S. N.

" *Thou too, sail on, O Ship of State!* "

INTRODUCTORY.

The rivalry that has always existed between civilized nations in striving to develop the most powerful vessels of war and the best talent for handling them, has resulted, of late years, in the production of ships of enormous size, great speed, and intricate arrangement of parts; of armor of great thickness, improved quality, and wonderful resistance; of guns of enormous size, great accuracy, and extraordinary penetration; of engines of great variety, increased economy, and mighty power; and of warriors whose usefulness depends not only on personal valor, but on high scientific attainments and constant application in the use of complicated instruments of modern warfare. This rivalry has resulted also in giving great prominence to the torpedo as a weapon of attack and defence.

The vessels now possessed by foreign nations differ widely in type, size, class, speed, and power; each design emphasizes some particular feature which renders it either more powerful or more impotent than some other of equal cost; and foreign administrators, who have been actively engaged for many years in endeavoring to decide how to expend a given appropriation for defensive purposes in the most economical and advantageous manner, are obliged to acknowledge that the problem is still unsolved. It is, therefore, unreasonable to suppose that all the questions incident to a thorough and systematic reconstruction of our long neglected navy have been definitely settled as yet.

The subject under consideration is very comprehensive; involving unsettled questions of policy, type and administration, as well as many other topics of great importance; but, in confining myself within the prescribed limits, I shall endeavor to review concisely: (1) The type or character of the vessels needed; (2) The number of each type required; (3) How or where they should be built; (4) The time and money required to build them; (5) What is necessary to ensure the future maintenance of our fleet in an efficient condition, after its reconstruction is accomplished.

As one of the most important steps in the erection of any structure is to satisfy those for whom it is to be raised as to its importance and the firmness of the ground on which it is to rest, and as the details of my plan may possibly appear antagonistic to the popular impressions of the day, I shall begin the evolution of my theory by considerations which, while not appearing to fall directly within the scope of the essay, may add strength to the foundation.

I.

So long as men have different ideas of right and wrong, of justice and injustice; so long as men can be persuaded to lay down their lives in antagonism of an imaginary wrong, or in resentment of an insult; so long as men possess different degrees of patriotism or love of country, or can be influenced in different ways by religion, or have different views concerning the worship of a Supreme Being; so long as men are widely different in customs, habits, intelligence, valor and ambition—just so long will *war* be a necessary evil.

There are often noble reasons which appeal to the manhood of a nation and make men even delight in war. Nations that have been established on earth for the protection of liberty and the preservation

of independence, under their constitutions, are naturally proud to ensure freedom and safety from oppression. A manly people, when threatened by a national danger, is quick to defend itself, either by displaying its valor in the contest, or by burdening itself with the taxes necessary to enable this to be done.

Our constitution was founded on the broad principles of civil and religious liberty, and we have assumed the great responsibility of proving to the generations yet to come whether it will produce a race of men wise and strong enough to make justice, honor and bravery our national characteristics; whether it can develop those qualities which make nations great, and give them dignity sufficient to place them above others not yet free from the bonds of despotism. The constitution that cost our forefathers so much blood is still entrusted to our keeping, and it is our sacred duty to guard it with jealous care, to devote our intellect, our time, our money, and our lives, if necessary, as becomes the dignity of a noble nation.

In their relations with each other, and in many characteristics, nations resemble men, and a forcible comparison is often drawn between them. A child's strength and powers increase until he reaches manhood, when, if success has crowned his efforts, if disease or indolence has not checked his development, he is respected and admired. For a while he retains full possession of his strength and faculties, after which he undergoes a process of physical decay.

So nations have arisen from a weak infancy to a manhood of glory and power, and so have they faded until they have been swept into the gloom of an eternal night, leaving little more than a few lines on the tablets of history to record their virtues and the causes of their fall.

Since Egypt, Greece and Rome were at the zenith of power and glory, great changes have taken place in the map of the world; and even now we can point to nations which appear to have passed their zenith and to be descending towards the horizon of their glory. Other nations are still in childhood, on the road to manhood, and time alone can tell whether they will profit by the experience of their predecessors.

Is it possible that with us the seeds of decay are already sown? If public lethargy in matters of national defence be any indication, we must acknowledge the sad reality.

Still, the disease may be only temporary, and judicious effort may

enable us to effect a cure; and if this is to be effected, we should bear in mind that a *temporary* cure, from the laws of action and reaction in government administration, might be worse than no cure at all.

Unlike men, however, nations may live forever in the full vigor of manhood, since with them decay is a direct consequence of their own errors, and may be avoided. With man, it is only his physical being that is necessarily affected; with nations, the morality and wisdom of the people are attacked, and the resultant evils are, neglect of state affairs, corruption, effeminacy, loss of patriotism and, finally, dismemberment and ruin.

No man can do good in the world unless he develops those natural abilities with which the Creator has endowed him, and it is equally true that no nation will ever be able to exercise freely its capacity for doing good unless it develops the raw resources of national strength that a wise Creator has given it for the organization of national power. Political intrigue can act only against a nation in its decay, and against men too enervated to know their rights; and it follows that one of the highest objects of good government is to know where its weakness lies, in what its power consists and how it can best be applied.

The power of any nation lies mainly in the industries of its people. With us the principal industries are agriculture, manufactures and commerce, and they are all under the control of Congress, or of men variously interested in all. To complete the comparison, it may be assumed that Congress represents the head of a great *National Organism*, and that the principal source of life, the preponderating industry of agriculture, represents the body. The manufacturing and commercial industries, respectively, may be considered as the arms, which are essential for supply and defence, and as the legs which enable the body to extend its sphere of usefulness.

During the younger days of this active being his life was exceptionally full of dignity, health and vigor; and it is now to be hoped that, instead of continuing to relapse into a lethargic state of impotent corpulency, he will arouse and see the necessity for beginning a rigid and wise course of training to redevelop his limbs in proportion to the growth of his body, so that he may be able to extend his sphere of usefulness throughout the world and to maintain it during the coming ages.

If it be clear that agricultural industries prosper where such a

healthy physical state exists, it ought not to be difficult for Congress, the head, to institute this healthy and abiding reaction.

The development of those arms and legs may be accomplished in the reconstruction and increase of our Navy and Merchant Marine. The two services are so intimately related that they deserve equal attention; and the question of reconstruction in both cases becomes greatly simplified if our policy is guided by the mutual support they render, both in peace and war.

It will be my endeavor, therefore, to satisfy the demands of the Essay by directing particular attention to the Navy, with such brief allusions to its kindred service as will facilitate the formation of a reconstruction policy in both cases.

II.

The evil results of our construction policy since the Civil War are too apparent to need much comment. That policy was founded on the maintenance of what is indefinitely termed a *peace navy;* and if it is to be understood by its results that only such ships as are absolutely worthless for the protection of our national honor are required, nothing more is needed than to continue administering large and frequent doses of repairs to our present impotent fleet. A "peace navy," pure and simple, that is not created and maintained for the purpose of occupying a prominent part in national defence during war, results in many worse evils than the production of ships that are worthless for any purpose, except perhaps to form sunken obstructions in the channels of our harbors in the hour of danger; its impotency has an injurious effect on our national prestige abroad, and subjects us to the ridicule of those nations whose respect may affect our peace and prosperity; it is apt to cause inefficiency and stagnation in those charged with its maintenance and care; it destroys that pride and zeal in the execution of duty among the officers and men obliged to parade the neglect and weakness of their country before the eyes of more thoughtful nations, and it reduces to a state of inefficiency the "nucleus" on which we must depend for the expansion of our war power in time of danger.

The duties of a navy in time of peace are many, but the most important may be enumerated as follows:

(1) To form a "*nucleus*" for the expansion of our naval power for national defence in time of war.

(2) To guard the "*prestige*" of our flag, and command the respect of other nations in times of peace.

(3) To maintain a "*school*" for the training and discipline of officers and men, and thus provide for the efficient expansion of our personnel in time of war.

(4) To further the "*interests*" of civilization and commerce, by affording protection or relief to American citizens domiciled under unstable governments or in semi-civilized countries.

(5) To "*investigate the complaints*" of our citizens whose interests are abroad, against alleged injustice on the part of distant civilized nations.

(6) To "*aid or succor*" whenever possible the distressed people of all nations, in the interests of humanity and courtesy.

(7) To "*observe*" and "*keep informed*" of the progress of other nations in the science of warfare.

(8) To facilitate the "*scientific investigation*" of subjects connected with maritime and national interests, and to execute the surveys of obscure harbors abroad and of our own coasts.

(9) To assist in suppressing "*internal riot.*"

(10) To enforce the "*laws of neutrality,*" and prevent other powers from doing it for us.

The first and most important of these duties demands that our *matériel* and *personnel* be maintained in the highest state of efficiency. A school for the training of officers and men will be of little value unless it provides the instruments which will be employed and teaches the principles which will govern their use when the crisis comes. Therefore, unless it can be shown that the more subordinate duties of our navy in time of peace can be performed by an efficient war nucleus, it is evident that we must maintain two or more establishments of a different character, one for peace and one for war. But what ships do we require to form an efficient nucleus?

While in such an investigation a due regard for economy is of paramount importance, still, in conforming to its demands we must not lose sight of the *object* to be attained; for if we disregard this and produce something not needed, we will be guilty of the worst kind of extravagance. Therefore, in determining the character of our nucleus, it is necessary to know what nation is our possible and most formidable enemy, and what the ships composing that nucleus would be called upon to do in the event of war with that enemy.

III.

If we subject our national neighbors to a physical examination we shall find that the nearest and most dangerous is England. Behold

a wonder of physical development! Brawny arms, the influence of which is felt the world over; active legs that seem fully adapted to perform all their functions; and a body, invigorated by blood that springs from an ambitious heart, still in the infancy of development. Is it not possible then, unless we are prepared to command the respect of this active and vigorous neighbor, our once disagreeable parent, that the friction resulting from his proximity may erelong cause the "electric current of imperial power" to make its decomposing effect felt among the elements of our composition?

The accompanying map illustrates the situation, but I shall quote a few extracts from various papers and discussions of the Royal United Service Institution, which are forcible in their original forms and will save the trouble of an extended military study of the situation, a study not called for in this essay, but which seems important to show what work the ships we build may have to perform. The spirit that actuated the studies from which I quote cannot fail to command our admiration, and is certainly worthy of our respect.

"The question is treated merely in a military, and, it is to be hoped, philosophic spirit such as cannot give offence to our kinsmen of the great Anglo-Saxon Republic, with whom the most friendly relations exist; but they have not always been able to restrain the lawless bands of Fenians and their sympathizers who have from time to time raided across our frontier. . .

"Civilization and progress have already commenced to shift from the basin of the Atlantic to that of the Pacific. At this moment what has happened to the Suez Canal is happening with regard to the railroads across America . . . and nobody can watch what has been the effect on the commerce in the Pacific without observing that it is in like manner being diverted towards the States. The only possible way for us to get it in the future is by the Canadian railway. We should, however, not only regard this railway from the standpoint of its strategical value to Canada, but as vitally concerning British power in the Pacific, and as the key to British power in the future to command the sea on the other side of the world. . .

"The completion of the Canadian Pacific Railway is not merely a vital necessity to the integrity of the Dominion, but of the Empire. . . . The shortest way from Ireland to Japan by a thousand miles would be the great circle of the globe along which this railway runs. By it will return the costly silks and teas of China, the products of the Spice Islands, of Australia and India, the cotton of Feejee, as well as the grain of the great valley of the Saskatchewan. . . . In six days from Montreal, in thirteen days from Liverpool, we shall be able to reach the Pacific. . . . It puts us in a better case to take up the defensive position, the offensive-defensive, to fit out and strike from there, to defend our coasts and our commerce, by as much as possible carrying the war with all its disagreeables into the enemy's coast and positions. This railway . . . will, at the present rate of progress, be completed in 1885.

"Surely British merchants don't need to be taught by British soldiers that commerce means empire, and *vice versa.*

"Canada has already led the way by proposing differential duties against the United States, manifestly in favor of Great Britain. . . . Here is a great field for our surplus population, if England has not lost the imperial faculty of organizing arrangements for her people. . . . At the present time your food supply is in the hands of foreign powers; but supposing this railway to be made, you would then have, within 14 or 15 days of England, this enormous British tract of the best food-producing land in the world, and which, when got at, would, I believe, maintain its food-producing power against the whole world.

"As the United States have allowed their navy to fall into a state approaching effacement, the duty of maintaining order on those seas, and protecting the rights of neutrals (even if we ourselves do not become principals in a war) devolves on the squadron we maintain in the Pacific. . . . There is no doubt that in time of war, if the United States were neutral, we should have trouble. The strongly marked line shows the boundary between the United States and the British possessions, but I believe an enemy lying within three miles of their coast would be in so-called neutral waters, and there are plenty of harbors in which a vessel could lie and shelter till an opportunity offered to strike a blow.

"The same physical causes that have contributed to England's greatness will to a certain extent create in Vancouver's Island, in no very remote future, a prosperous country. . . . The coal, iron, gold, and splendid timber not far from a series of magnificent harbors, will make Vancouver a trade starting-point from America for Asia—as England has been from Europe to America. If there is any truth in Buckle's 'History of Civilization,' Western Britain will be great when the Californian, receiving no fresh blood from Europe, has degenerated into the *sans souciance* of the Southern European.

"Canada is a long strip of communications, its main artery, the St. Lawrence, being the fosse of a natural fortress, open during the summer season to the gunboats of Great Britain, and to them alone, as long as the fortress of Quebec is kept in a defensive condition.

"The character of the country, which is a riband of interior lines, land and water communications, would facilitate the concentration and launching of an offensive force, which might surprise even 40,000,000 of unarmed people who have hitherto relied upon their ever successful diplomacy. . . . A combined military and naval force, therefore, started from Canada at the first declaration of hostilities, might, by giving up their communications in the rear, push on to the Atlantic coast as Sherman did, and seize an important seaport, there to co-operate with the British fleet which could support them, and form a fresh base for further operations, while an expedition from India might land a force of British troops and a Sikh contingent on the Pacific seaboard. Therefore *coute qui coute*, the command of Lake Ontario must be secured and maintained. Here Canada is at an advantage, the best harbors being situated on her shores, and the greater number of the steamers trading on the lake being held or manned by Canadians. It is hoped that we shall on the Lakes also so far take

the initiative recommended by Mr. Brassey, M. P., by encouraging a volunteer naval reserve on Lake Ontario. . . . In Canada there are registered 37,235 sailors, but in addition, Canada owns 1185 sea-going steam vessels, to act as transport and supply vessels."

If it be true that the "railway is the pioneer of progressive settlement," a network of railways and canals may soon make a populous country of the great British Northwest, and immigration develop a new *El Dorado.* Capital is flowing into this wonderful country, and the products of the soil are beginning to ebb into European channels.*

We wish our cousins well, and admire the spirit of enterprise that has always characterized the Anglo-Saxon race; and we believe it cannot give offence or do aught but increase their respect for us if we also devote a little attention to the question of national defence from a philosophic military standpoint.†

For defensive purposes we have the advantage of being a homogeneous UNION, but we are almost entirely surrounded by a chain of water communications all open to the war ships of England, while the most important link is closed to our own. If we were to assume a strictly defensive attitude in the event of war with that power, whose principal base of operations is the open sea, we should be subject to unexpected attacks from almost every point of the compass. Our attention would be drawn towards the defence of some threatened portion of our territory by a well-organized feint of the enemy, while his main efforts would be directed towards some more important objective where we least suspected danger. It is evident, then,

* A seaport exists in the heart of the American continent, nearer to Liverpool than is New York, where land capable of supporting an agricultural population exceeds 200,000,000 acres. See accompanying map.

† I am well aware of the diversity of views, sanguine and otherwise, concerning the future of our neighbors in the north; but, consider, although it is possible the Canadian Provinces may eventually become United States territory by request, that we should accept the situation as it exists, and show the world that we are prepared to protect our neighbors if they choose to link their destinies with ours. In confining these preliminary observations principally to our northern interests, the fact is not lost sight of that there are ominous warnings to the southward, and that the influence of foreign powers in the future control of the American Isthmus Canal may yet cause us trouble; but if we were prepared to command the respect of Great Britain, it would be safe to assume that our interests would not suffer at the hands of any aggressor.

that our wisest policy would be to assume a vigorous offensive. By this I do not mean the invasion of England, because such an operation would necessarily be performed at too great a distance from our own base of supplies, and against a powerfully concentrated, well protected force; but we could lay siege to the heart of this great nation by offensive operations against the arteries leading to it. It would, however, be a mistake to suppose that we could paralyze those arteries or communications by pouring forth our hordes from the Mississippi Valley into Central Canada; because this operation would simply tend to roll up or concentrate the enemy's strength along his perfect lines of communication towards his points of support and bases of supply. Furthermore, the time in which such an operation could be performed would necessarily be limited by the severity of the long Canadian winter, which would render such an operation barren of anything but disastrous results to our own deserted bases.

That valuable strip of territory comprising the Eastern and Middle States is singularly exposed to the coöperative attacks of the enemy from both north and south, while our own offensive operations from the land side are limited to the seizure and occupation of such strong objective points as the Welland Canal, Kingston, Ottawa, Montreal, and Quebec, all of which, to ensure free access to England's war ships and transports, will soon be well fortified. The Canadian canal system is being rapidly perfected in order to draw the Western grain trade away from the United States, and if, as it is contemplated, grain ships will soon be able to load at Chicago and discharge at Liverpool, this system will admit larger war-ships to the lakes than will our own canals.*

* Our treaty with England in respect to armaments on the lakes dates back to 1817, when, after the war of 1812, it became desirable to reduce the armament of both nations in those waters. That treaty permitted the continuance of four vessels, each "not over 100 tons," and armed with "one 18-pdr. cannon," one vessel on Lake Ontario, two on the upper lakes, and one on Lake Champlain. It stipulates that "all other armed vessels shall be forthwith dismantled and no other vessels of war shall be there built or armed," and agrees that either party can annul the stipulation after a six months' notice; and that the service of each government shall in no respect interfere with the proper duties of the armed vessels of one another. In 1841 $100,000 was appropriated by Congress for the construction of an armed vessel to suit the change in circumstances, and the Michigan, of over 500 tons, built at Pittsburgh, was put together and launched at Erie in 1844. This action was caused by the employment of vessels of equal or greater power at various times by the Canadian authorities in

Our enemy's rear is protected by the frozen regions of the north, and it is probable that offensive land operations would be disastrous to us if we left our own flanks and rear open to attack either from British Columbia, Canada, Bermudas, or the English possessions in the West Indies; but his communications can be severed at sea, and this, to my mind, seems to be the most effective line of operations.

From the foregoing considerations, then, it is probable that our enemy's offensive operations would be, chiefly, as follows: To blockade, bombard, capture, destroy, or ransom our important seaports, lake cities, shipping, and naval establishments; to seize and fortify important strategic points on our northeast or northwest coast and frontier; to raid our Atlantic and Pacific seaboard, cut off a strip of territory from each exposed corner, occupy the mouth of the Mississippi, and dictate terms of peace, with his communications unexposed in rear, all around our territory.

Our attention, then, on the opening of hostilities, should be directed towards:

A. Preventing the blockade, bombardment, destruction, or seizure of our shipping centres and naval establishments; in order that our cruisers may have free access to their bases of supply, and that the rapid expansion of our war power may suffer no check.

B. Intercepting the enemy's transports, convoys, and war material in transit to his bases near our territory; in order that those bases may not be strengthened and the enemy's war power concentrated near us.

C. Intercepting the enemy's food and industrial supplies in transit to the seat of government; in order to create panic and hasten a capitulation.

D. Organizing expeditions of attack against the enemy's colonial bases; in order to coöperate with our army in the final destruction of his power to harm us on this continent.

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the police of those waters against the aggression of so-called "Canadian Patriots," and after a remonstrative correspondence on the part of England, extending over a long period of years, seems to have been considered satisfactory by the British authorities. The "six months" notice was given by Secretary Seward during the Civil War, but no vessels were built, and it was annulled after the war. The original treaty is still in force, but it seems to have been tacitly admitted that the combined power of all four vessels can be united in a single one. It is a serious question now whether the United States should not have the exclusive right to maintain an armed force on Lake Michigan, which lies wholly within her territory, so long as Great Britain has the right of free access to the lakes with all her armed force.

IV.

I have prefaced this investigation with the assumption that in conforming to the demands of economy, if we lose sight of our object and produce something we do not need, we shall unconsciously be led into extravagance. This fact is apparent in the modern constructions of all nations who have been striving for a number of years, in the race between guns and armor, to produce a *perfect fighting ship*. Such a ship is impossible, because it should possess all of the following qualities, some of which are irreconcilable:

Great Speed,
Great Endurance (of propulsive power and supplies),
Great Offensive Power,
Great Defensive Power,
Sea-worthiness,
Handiness,
Steadiness of Platform,
Light or moderate draught of water,
Habitability,
Smallness of Target.

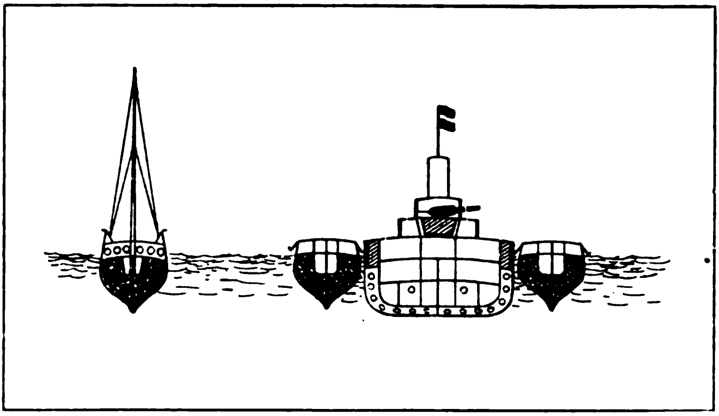
As we wish to avoid the errors of others, I shall endeavor, in the selection of types, to conform strictly to the services required of them, as enumerated under the four separate headings, referring to above as A, B, C and D.

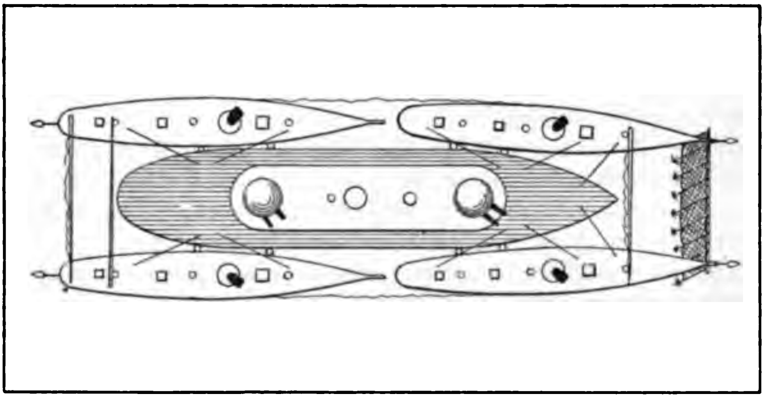
(*A*) *To prevent the blockade, bombardment, or destruction of our shipping centres and naval establishments.*

An enemy engaged in blockading a port defended by forts and torpedoes only, would operate out of range of the forts; his ironclads would lie at anchor, with torpedo nets or other obstructions around them, and the active vessels of the fleet would rely upon their speed, their electric lights and their rapid-firing guns for defence against torpedo boats. A bombardment or seizure could also be attempted with reasonable prospects of success by the present type of ironclad coast-defence vessels, even if the harbor were defended by forts, rams, torpedoes and torpedo boats. One method might be as follows:

The ironclads should be accompanied by torpedo-proof "auxiliary supply vessels" of moderate dimensions, three-masted schooners, for example, which in bombardment would be useful as mortar boats.

While entering the harbor these vessels would be secured abreast of each ironclad, as in the sketch, by steel hawsers, their spars lashed





across ahead and astern of the ironclad. Double torpedo nets would depend from the spars, the foremost one having sharp-horned grapnels attached to its bottom edge to cut the wires of submarine mines, and spar torpedoes would project from each of the smaller vessels for defence against rams. A further defence against submarine mines, in the shape of counter-mines, might be provided for by discharging submarine rockets ahead at short intervals. The Thunderer could steam under such circumstances six or seven knots.

I do not argue from this that submarine mines and torpedo-boats are useless in the defence of ports; on the contrary they are ex-

tremely useful auxiliaries, and very necessary to force an enemy to adopt cumbersome precautions: but I do conclude that ironclads are the most useful auxiliaries to prevent the destruction of our shipping centres and naval establishments, and that they are *indispensable* to raise a blockade.

The vessels required to perform this duty would operate at or near their bases of supply, in waters which would limit their spheres of action to the vicinity of the places they would be called upon to protect; and their chief functions would be to obstruct the passage to the enemy's vessels, and to destroy or put them to flight. In fact, if they combine the invulnerability and great destructive power of armored land fortifications with a moderate degree of the mobility of ships of war, they can oblige the enemy to keep the sea, at such distances as will not compromise the safety of the cities, or the safe passage of our cruisers out of the harbors.

Therefore, if we must sacrifice some of the qualities necessary to a "perfect fighting ship," and if we can safely assume that speed and endurance are of secondary importance, our naval constructors will find no difficulty in producing vessels which will possess the other desirable qualities to a satisfactory degree. If, however, we reduce them to the condition of mere "floating batteries," we limit their spheres of usefulness to the localities in which they are placed, which will necessitate a number sufficient to close all the important harbors against attack along our extensive seaboard; and, inasmuch as the enemy cannot bring floating batteries against us to execute the important operations in question, we shall lose nothing in comparison with the enemy's ships, if we sacrifice enough of the offensive and defensive powers of that class of vessels to enable us to divide the work of concentration, at the different strategic points, among a smaller number of vessels possessing a moderate amount of mobility.

Owing to the great increase in power of modern ordnance, it is impossible for ships to carry armor sufficient to render them impregnable at all points. Recent and further contemplated improvements in the resisting power of armor, however, will enable us to increase the shot-resistance of the small area enclosing vital parts, to any desired extent. The armor thickness may be safely carried to three feet or more, and although it is possible to construct guns capable of penetrating this, it is evident we have about reached the limit weight in guns, any increase in which will render their fire w to be of practical value. But if these vessels are to be de-

prived of great speed, they must possess a certain amount of invulnerability to the enemy's rams, torpedoes, and torpedo boats. Their want of speed or engine power also deprives them of that cumbersome alternative, the use of torpedo-proof auxiliary vessels, as previously suggested; but this difficulty can be overcome and the desired invulnerability may be gained, by *combining the ironclad and the cordon of auxiliary vessels in one ship*; and this, to my mind, is the solution of the problem of coast defence in the future.

In order to be able to move from one threatened centre to another, these vessels will require a moderate amount of endurance; their trips will be coastwise, and they will require to be invulnerable at sea and in rough harbors; therefore they will require steadiness of platform and a moderate degree of seaworthiness. As light or moderate draught is an element of defence as well as of offence, particularly in operations on our coast, it is therefore also important in these vessels.

It also appears that the vessels on which we must rely to perform the services under *A*, would be well adapted to perform the services *D*, that of "*Organizing expeditions of attack against the enemy's colonial bases*," since the principal of those bases are uncomfortably near our own territory; and we may regard the requisites of that type in the order of their importance as follows:

TYPE I.*

(1) Great Defensive Power.
(2) Great Offensive Power.
(3) Steadiness of Platform.
(4) Light or moderate draught of water.
(5) Moderate Endurance.
(6) Moderate Speed.
(7) Seaworthiness.
(8) Handiness.
(9) Smallness of Target.
(10) Habitability.

* I have long thought that "torpedo protection" would eventually neutralize the terrible destructiveness of that weapon, and now I am confirmed in my belief by the invention of a "torpedo-proof ironclad" by that eminent authority, Sir E. J. Reed—late Chief Constructor, British Navy—whose patents, although not yet given to the public, we may readily conceive. If we confine the machinery, heavy guns, and ammunition to a moderate space, thoroughly pro-

There are two classes or divisions of this type required both for the defence of our harbors and for attacking the enemy's bases. The hydrographic features of the harbors of our Atlantic and Pacific seaboards adjacent to the St. Lawrence and Vancouver respectively, will admit deep-draught vessels, while most of those along our Gulf and Atlantic ports south of the Chesapeake will admit moderate and light-draught vessels only. It so happens that the vessels suitable for the defence of our northern ports will best serve as attacking vessels at the mouth of the St. Lawrence and Vancouver, while the light-draught vessels suitable for the defence of our southern seaboard will best serve as attacking vessels for either Bermudas or the Great Lakes. The Bermudas are naturally protected by a long line of coral reefs, extending several miles to seaward, and leaving a narrow and tortuous channel at one end of the group of islands, well protected by armored batteries. Light-draught vessels, however, drawing not more than ten feet, could enter the dockyard unopposed, by passing over the reefs to northward of the groups. These same vessels, starting from some point on the Mississippi or its tributaries, could pass either to threatened points on the coast, or to the Great Lakes by way of the Hennepin canal, which it is hoped will soon permit the passage of vessels drawing at least ten feet.

There is another feature of our coast which gives us great advantage in coast operations and which should be further improved for defensive purposes, and that is the inland coast water route. Vessels of light draught can go from Florida to Buzzard's Bay without being obliged to put to sea, and when the Cape Cod and Florida canals are finished, this route will be extended from Boston to Pensacola, with the possibility of extending it to Galveston if the interests of trade

tected by heavy armor above and by light armor below the water line, and surround the citadel thus formed by a raft-body composed of numerous compartments, we can produce a vessel that will be unsinkable by *several* blows of the ram and torpedo. Such a vessel could carry the unimportant stores and fuel, except enough for immediate use, in the nearest cells or compartments, with water-tight door communication to the citadel; some of the cells could be filled with cork if necessary; and the whole auxiliary structure could be constructed of very light plates, with the exception of a strong fore-and-aft bulkhead, which would give the raft portion of the structure strength enough to ram. By thus limiting the speed and endurance we can avail ourselves of the advantages of great beam, which in turn renders it comparatively easy to combine steadiness of platform, handiness, light draught, habitability, and smallness of target in one vessel.

demand it in future. This inland navigation route is particularly adapted for the movements of light torpedo boats and gunboats. A number of swift torpedo boats, kept in the vicinity of New York or the Hudson River, could be quickly transported either by canal or railroad to the Lakes, and would there form a valuable means of defence against the enemy's gunboats and extemporized merchant cruisers.

The two classes of Type I may be roughly described as follows:

TYPE I.

QUALITIES.	CLASS (*a*)	CLASS (*b*)
(1) Defensive Power.	Armor so arranged as to afford complete protection to the vital parts of the ship. Protective arrangements by water-tight compartments sufficient to render destruction by ram and torpedo problematical or doubtful.	Same.
(2) Offensive Power.	Ram. *At least* 2 "high-power" B. L. R. of 15″ calibre; 6 rapid-firing 6-pdr. rifles; 2 5″ B. L. R., "high-powers"; 4 torpedo-discharging tubes.	Ram. *At least* 1 high-power B. L. R. of 12″ calibre; 4 rapid-firing shell-guns, 6-pdr.; 2 5″ B. L. R. high-power; 4 torpedo tubes.
(4) Draught.	Not more than 18 feet.	Not more than 10 feet.
(5) Endurance.	Steaming capacity, about 3000 miles.	Same.
(6) Speed.	About 8 knots.	Same.
(7) Seaworthiness.	Capable of making short passages at sea in rough weather.	Same.
(8) Handiness.	Capable of turning readily when going either with or against the tide or current.	Same.

The next duty imposed upon our fleet is that of — (*B*) "*Intercepting the enemy's transports, convoys and war material, in transit to his bases near our territory.*"

No demonstration is required to show that the most effective plan would be to blockade the British Isles; but as it is not probable, nor even necessary, that our "peace footing" will ever be strong enough to meet the enemy's concentrated war power in those waters at the opening of hostilities, such an operation could not be successfully performed. By the time that our ships were ready to commence offensive operations, English transports would be under convoy from the British Isles and India, with the object of concentration on our northeast and northwest frontiers; and as their operations from Bermuda would be of secondary importance, our best blockade would be that of the two principal objectives, the St. Lawrence and Vancouver. If we had vessels enough of Type I to seize and render those bases inoperative with the first notes of war, an effective blockade might possibly be maintained; but we could not count on such an operation for the solution of the difficulty, since it would be possible for England to assemble a large fleet of ironclad coast-defenders at each of those places before the declaration of war. Furthermore, the *rôle* of Type I at the opening of hostilities is undoubtedly to defend our exposed flanks on either seaboard. The blockade of these two objectives, therefore, during the first stages of the war, should be performed at sea; in accomplishing which we could create a diversion towards the lines of communication, draw off the enemy's coast-defenders, and pave the way for the culminating operations of attack.

The enemy would thus be obliged to protect his lines of communication at sea by ironclads, and a fleet of unarmored cruisers would be unable to do him any serious damage on either of his main lines. In executing such an operation as this, we should have the advantage of acting strictly on the offensive, while our adversary would be obliged to assume the defensive of what on the high seas may be regarded as detached or isolated bases; and inasmuch as the difficulties of his defence would increase with the size of his convoys, the number of vessels composing each convoy would necessarily be limited, and our offensive power on those lines should not be too highly concentrated. Therefore I conceive that we would require a scattered fleet, cruising on each of the lines, and that each vessel should possess power enough to engage the enemy's ironclads singly, if necessary. These vessels should be unencumbered by others of a

weaker class, which they would be called upon to protect; in fact their character should be preëminently *self-reliant*, *independent*. Their qualities may then be regarded in the following order of importance, viz.:

TYPE II.

1. Great Speed.
2. Great Endurance.
3. Great Offensive Power.
4. Great Defensive Power.
5. Seaworthiness.
6. Steadiness of Platform.
7. Habitability.
8. Draught of water, limited only by the channels leading to their bases of supply.
9. Handiness, as great as is consistent with the attainment of the more essential qualities.
10. Size of Target, as small as is consistent with the attainment of the more essential qualities.

It needs but a glance to show, that to meet these requirements, nothing less than a first-class modern "battle-ship" will suffice.*

The ships that we must depend upon to perform this important service should be at least as powerful as the "battle-ships of England." There is a limit to the size of ships, which depends upon the quality of the material of which they are constructed; but it is apparent that the limit has not yet been reached in the construction of stout "protected," steel "battle-ships." I do not maintain that the Italia and Lepanto are perfect ships of the type they represent, that ships fully as powerful cannot be built of less displacement, but I do claim that, however much their proportious may be reduced, the largest ships can be made the most powerful on the high seas. It may be objected that the depths of the channels leading to our bases will prevent our building very large ships; but we should consider that the tendency

* The Italians have been the first to discover the future type of "ocean monarch," and our conservative cousins, as usual when a decided change of tactics is necessary, are reluctantly following in their wake. The Anson, Benbow, Camperdown and Collingwood, of 10,000 tons displacement and 16 knot speed, although powerful ships, can never be a match on the high seas for an Italia or a Lepanto of nearly 14,000 tons and 18 knots speed, workmanship and personnel being equally good in each case.

of improvement in modern naval architecture is towards the increase of beam, in producing increased capacity for speed and increased stability combined with steadiness, and that increase of beam permits decrease of draught.*

Table Showing Depths of Channels leading to Principal Ports.

Ports.	Depth on Bar.	Rise & Fall of Tide.	Ports.	Depth on Bar.	Rise & Fall of Tide.
	Feet.	Feet.		Feet.	Feet.
Eastport, Me.	48	18	Philadelphia, Pa.	24	6
Portsmouth, N. H.	36	8.6	Baltimore, Md.	24	1
Boston, Mass.	22	10	Norfolk, Va.	20	2.7
Provincetown, Mass.	36	9.2	New Orleans, La.	24	0.6
New London, Conn.	21	2.5			
New York, N. Y.	23	4.8	Seattle, Wash. Ter.	25	12
Wilmington, Del.	24	5.7	San Francisco, Cal.	33	3.
Chester, Pa.	24	5.7	San Diego, Cal.	21	4.

A glance at this table will satisfy us that the load draught of our battle-ships can safely be placed at 24 feet, and I think it is safe to say that we can satisfactorily combine all the desirable qualities as enumerated for Type II, in a displacement of 11,000 tons, and at a cost of about $3,500,000. If, however, the object could not be attained in a ship of that size, I see no reason why we should not build ships of 15,000 tons or more, unless we decide, as our English cousins are inclined to do, that future engagements on the high seas will invariably result in victory for the ship which possesses the best qualities for ramming.

If "ramming tactics" are to be the first resort in future engagements, our best policy would be to make all other offensive weapons subordinate, and, possibly, to build sea-going rams pure and simple. When the battle of Lissa was fought, coast defence ironclads were not built to

* The Russians have demonstrated that a ship of 5000 tons displacement, drawing 7 feet of water, 235 feet long and 153 feet beam, can be driven at the rate of 16 knots, and during a fierce gale in the Bay of Biscay, acquit herself as thus described by Ex-Chief Constructor Sir E. J. Reed, a passenger on board: "The actual rolling and pitching of the Livadia at the height of the gale was exceedingly small, never exceeding 4° for the single roll, or 7° for the double roll, or 5° for the forward pitch and 9° for the double pitch, so to speak. This horizontal steadiness was most remarkable, and, while in very agreeable contrast with my experiences of the last three years at sea in ordinary ships, was full of significance as regards possible steadiness of gun platforms in ships of war."

be impervious to a single blow of the ram, and the torpedo was in the infancy of its development; now, the conditions of naval warfare are changed, and in future engagements, particularly where the sphere of action is unlimited, as on the high seas, ramming will be a last resort. My reasons for thinking so are: (1). The development of the torpedo will render the destruction of sea-going ships almost certain at short ranges. Moving torpedoes may be regarded as a species of projectile, the range and efficiency of which will, in the natural course of improvement, be continually increasing. (2). The possession of powerful guns by one of two antagonists will enable that ship to multiply the chances of delivering blows, almost equal in power to the ram of a small ship, at safe distances outside the zone of effective torpedo offence.

If I meet an enemy at sea intent on ramming and I am determined to try my skill with guns, he cannot possibly succeed in delivering his blow, unless he possesses greatly superior speed, without finding himself in my wake, where he must remain so long as I choose to keep him there. In such a position I would have the best of opportunities for using my stern torpedoes, which would be effective even if towed at the end of a hawser, and my chances would improve for hitting him, the nearer he approached my stern. If I possess a "stern-ram"—such a thing is not impossible—and all my previous efforts to cripple him have proven futile, I can ram with equal chances of success, at a moment when he least suspects it. If I possess superior speed, I can keep to windward and obtain the benefits of that potent auxiliary, the smoke from my guns, which will render his aim uncertain and destroy his power to avoid my torpedoes. If he possesses superior speed, the chase may be mainly to leeward, but he will still be in my wake, and the smoke in this case as disagreeable to the pursuer as to the pursued.

Unless my adversary is greatly superior in speed or prefers to follow in my wake, we must eventually engage broadside to broadside. If I possess a few long-range heavy guns, and his battery is composed of numerous light ones, his object will be to engage at short ranges, which I can prevent by again bringing him in the dangerous wake.

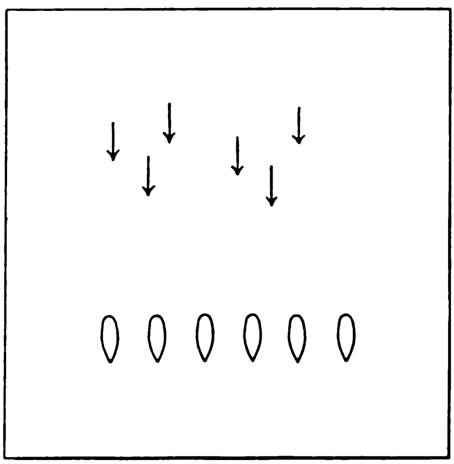
If future engagements at sea are not to be fought at long range, ought we not to inquire what chances of success the Chicago would have against a "torpedo cruiser" with displacement, speed, endurance, and armor-protection equal to that of the Chicago, but armed with

40 or more 6-pdr. "rapid-firing guns," 10 or more torpedo guns and tubes, some above and some below the L. W. L., and 2 6-in. "high-powered" B. L. R. armor-piercing guns? In a mêlée, or ramming attack at close quarters, I think the Chicago's battery would soon be placed *hors de combat* by the rapid fire of the numerous light guns of her enemy, aimed from the shoulder, even if the torpedoes did not give the *coup de grâce* before collision.

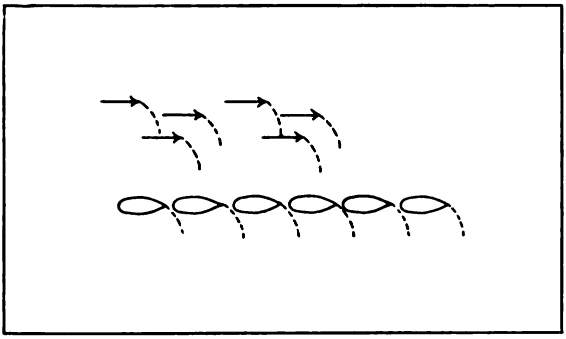
Some authorities declare, however, that ramming tactics should be adopted in fleet actions, while agreeing they should be avoided in naval duels, and as our battle-ships are to be qualified for squadron or fleet service, should occasion require, this phase of the subject also requires a brief investigation.

We may safely assume that a convoying fleet would never adopt the plan of avoidance, and leave its transports and supplies to the mercy of our vessels. But suppose our enemy unencumbered and free to engage, with intent to adopt "ramming tactics."

If we adopt either single line abreast or simple column of vessels, as our preparatory formation, we can manage, by the simplest evolutions of turning through so many points and then changing course to suit the circumstances, to bring the enemy in our wake. We shall then be in single line abreast, and if the enemy follows in his favorite ramming formation, that of "groups" or "pelotons," he will be at great disadvantage from the converging fire of our own guns and torpedoes, and at the same time his ships will be badly placed to render his necessarily diverging fire effective.



s equally patent, that if the enemy were to assume the group tion, with a view to eventually cutting off our rear vessels, steaming in line ahead on parallel courses, his position would ll worse with regard to the effect of the respective fires, and uld readily bring him again in our wake, if necessary.



COMPARISON OF LATE HIGH-POWER GUNS.

Computed according to "Maitland's Formulæ."

Gun.		Projectile.		1000 yds.		2000 yds.		3000 yds.		4000 yds.		5000 yds.	
nd Calibre.	Total Weight, tons.	Weight of Battering Shell, lbs.	Bursting Charge of Common Shell, lbs.	Time of Flight, sec.	Penetration, inches.	Time of Flight, sec.	Penetration, inches.	Time of Flight, sec.	Penetration, inches.	Time of Flight, sec.	Penetration, inches.	Time of Flight, sec.	Penetration, inches.
n, 5-in....	2.6	60	4.	1.6	9.2	3.4	7.7	5.7	6.3	8.3	5.3	11.3	4.7
5-in....	4.9	100	6.2	1.5	11.3	3.3	9.6	5.4	8.1	7.8	6.8	10.5	6.2
8-in....	12.3	250	13.	1.5	16.1	3.1	14.3	5.1	12.7	7.1	11.3	9.5	9.9
10-in....	21.6	500	20.	1.5	21.3	3.1	19.4	4.9	17.6	6.8	16.1	8.7	14.7
12-in....	43.	800	30.	1.5	25.2	3.1	23.5	5.0	21.9	6.4	20.5	8.2	19.6
17-in.....	100.	1800	70.	1.7	28.6	3.4	26.9	5.3	25.2	7.4	23.5	9.4	21.9
15-in.....	63.	1700	50.	1.4	32.7	3.0	30.9	4.6	29.2	6.4	27.4	8.2	25.9

inspection of the preceding table and "Graphic Comparison" ıow three things: 1. A large capacity for bursting charge being ble in common shell, it is not probable that the calibre of the ɜst guns will be much reduced in future. 2. Armor protection ɪe sort will be necessary to prevent penetration by heavy com- hell. 3. No matter what the result of the "race between guns

and armor," it would be folly to build unprotected ships to engage protected ones.*

The chief characteristics of our battle-ships, then, may be briefly described as follows:

TYPE II.

1. Speed,	18 knots, or at least as great as any battle ship contemporary with them.
2. Endurance,	*At least* 15,000 miles at reduced speed.
3. Offensive Power (with all around fire).	*At least* 2 B. L. R. of not less than 15-inch calibre; 6 B. L. R. of 6-in. or 5-in. calibre; 10 "Rapid Firing" Shell Guns, 6-pdrs.; 10 Revolving Cannon or their equivalent; 6 Torpedo Tubes.
4. Defensive Power,	A disposition of armor to afford as much protection as that of the Italian battle-ships, with particular attention to protection against fire from *astern*.
5. Seaworthiness, 6. Steadiness of Platform. 7. Habitability,	As great as possible.
8. Draught of Water,	Not more than 24 feet.

It may be argued, that if a simple increase in the size of ships yields such enormous advantages, we should not be satisfied until we had produced ships larger than the Italia; but there are many objections to be raised against the building of colossal ships, some of which, if of paramount importance, would weigh heavily against those we have selected. In a comparison between ships of the same type: the largest are deficient in manœuvring power; they require greater sagacity and attention in handling on the part of commanding officers; they offer an easier target for the concentrated fire of several smaller vessels; their superiority in speed loses much of its value when manœuvring in concert with more sluggish or slower ships; they are usually of greater draught, and their spheres of action on soundings is more limited; they require a longer time for their construction, armament and repair, and thus retard mobilization in case of war; they require special appliances for construction and repair, which cannot be readily multiplied in all ports without great expense; they demand a numerous personnel for their maintenance, and they are more exposed to accident on account of the increased complication of machinery.

*It is a mistake to suppose that "protected" battle-ships would necessarily be more deficient in speed than would unprotected ones, since in ships of such size the "protection" need affect "endurance" only.

There exists between the force of human intelligence and the instruments used by man a certain harmony of proportions which should never be disturbed. A child armed with the sword of a man would come to grief in combat with an adult less heavily armed, and yet a rifle in the hands of a diminutive sportsman would be more deadly than it would be in the hands of a giant unused to it. It is the aptitude and confidence of those who use an instrument of war that assure the victory; and so, if there be any advantage in the use of a massive instrument, there is no reason why we should not accustom ourselves to use it, unless we pass the limit of harmony in proportions where its efficiency in skilful hands cannot be regarded as greater than that of a smaller one in equally skilful hands.

We come now to consider what ships we shall require to,—

(*C*) *Intercept the enemy's food and industrial supplies in transit to the seat of government.*

England is forced to depend on either her colonies or the outside world for her food supply and the raw products which make her factories pulsate with vigorous life; and she will always be obliged to transport those raw products over a vast extent of the world's "great highway." She has about $800,000,000 of capital invested in ships upon the ocean, engaged in the carrying trade; and her capital invested in factories, and the number of subjects dependent on them, must be enormous. Uninterrupted supply is vital to her national life, and if it could be checked for a sufficient length of time, would undoubtedly produce starvation, anarchy and rebellion among those depending on it. Viewed in this light, our best plan of attack seems plain enough; but there are other considerations which place the matter in a very different aspect, and which may cause us to question the feasibility of striking so decisive and easy a blow.

In the first place, those goods for which she must depend on the outside world *are not contraband of war, and there is nothing in the laws of nations to prohibit their being carried by neutral ships.* In the second place, if we were to build a navy for the purpose of seizing those goods wherever found on the enemy's ships, *they would be carried in neutral bottoms* after the opening of hostilities, and we could not touch them without blockading all the ports of the British Isles. Such a blockade, as before noticed, would not be "effective" unless our navy were as powerful, at least, as that of England.

During the first stages of our Civil War, the Confederates possessed no "commerce-destroyers," and our merchant ships went

their way without fear of molestation. This fact led to the success of the Alabama, and now that name is used as a scarecrow. After the deeds of the Alabama became known to our shipowners, our flag disappeared from the sea, but commerce still continued. Is it not reasonable to suppose, then, that English capitalists with such interests at stake, would find a means of placing those ships under the protection of neutral registers with the first notes of war? Would it not be the wisest and safest thing for them to do, knowing the difficulties attending a blockade of the British Isles? And can we suppose that England would suffer greatly by the transformation, with the ships still owned by her subjects, and her shipbuilding establishments engaged in supplying a renewed demand for war material?

The only hold we should have on those ships under neutral flags would be when found with contraband of war on board; but the British Isles are bountifully supplied with that necessity, and such material in transit to the colonies would naturally be convoyed by English ironclads. Coal cannot be regarded as contraband of war in transit to neutral territory, and as England is not an importer of that article, her coal industries would not suffer. It is not probable, however, that this transformation would take place immediately on the opening of hostilities, unless the declaration of war were delayed for that purpose; still, owing to the constantly increasing facilities for communication with all parts of the world, by telegraph, such an event could be readily prearranged. No great difficulty would be encountered either in neutral or colonial ports; and even in our own ports, consular representatives and agents could be found through whom either neutral registers could be obtained, or the nominal ownership changed, if necessary. But the ships which happened to be actually on the high seas, or which had decided to run the risk at the beginning of war, might become a prey to our cruising ships returning home by way of the trade routes. Such ships would not be convoyed, but the enemy's cruisers would probably hover about the trade centres, at the crossings of the great routes, for their protection.

This great blow, then, would have to be struck with the first notes of war, after which our cruisers would become comparatively useless, unless they could be actively employed nearer home in the common defence of our coast, or at a distance in blockading the enemy's coast.

By reference to the following table it will be seen that those freight-

carrying vessels, either steamers or sailing ships, which compose the great bulk of the English merchant marine, do not make, on an average, more than 8 knots, and if armed with guns for self-protection, could carry a few only of light calibre. For the purpose of threatening this great freight-carrying fleet and forcing a transfer of flags—the *moral* effect of which, in foreign countries, would injure British interests to some extent—we would require as many vessels as possible to scatter over the trade routes for a short period; vessels which should be equipped and ready at the declaration of war, and naturally should form the greater part of our cruising fleet in times of peace.

Number of steam vessels belonging to the United Kingdom (exclusive of river steamers) actually employed, remaining on the register, 31st December, 1882 (from Annual Statement of Navigation and Shipping for the United Kingdom for year 1882):

Approximate Tonnage.	Home & Foreign Trade.		Foreign Trade Only.		Remarks.
	Number of Vessels.	Displacement Tonnage.	Number of Vessels.	Displacement Tonnage.	
Register 3000 tons & upwards.	21	108,166	21	108,166	
" 3000 to 2500 tons......	61	249,450	61	249,450	
" 2500 to 3000 "	127	420,570	127	420,570	
" 2000 to 1500 "	256	651,958	249	641,584	Note the large proportion belonging to these classes, with average speed 8 knots.
" 1500 to 1200 "	424	850,970	422	846,982	
" 1200 to 1000 "	390	643,890	388	640,641	
" 1000 to 800 "	469	629,224	454	609,404	
" 800 to 700 "	216	253,081	193	227,478	
" 700 to 600 "	227	220,234	155	150,468	
" 600 to 500 "	224	184,118	112	92,554	
" 500 to 400 "	299	202,113	119	80,964	
" 400 to 300 "	230	121,664	66	35,029	
" 300 to 200 "	212	80,541	44	17,032	
" 200 to 100 "	280	61,158	35	6,915	
" 100 to 50 "	229	24,938	11	1,263	
" 50 tons and under,	512	18,504	13	512	
Totals........	4,177	4,720,579	2,470	4,129,012	

How can we, then, strike this blow during the first stages of war in the best way commensurate with the results to be obtained, without expending the greater portion of our appropriation for reconstruction on a fleet of "commerce-destroyers"? No doubt a fleet of swift

cruisers of Chicago or Atlanta type could best perform the duty; but would the value of the object—that of capturing a very small portion of the enemy's merchant marine—justify the expenditure requisite to maintain, ready at all times, a great number of such vessels, when the duty might be performed by the same number of smaller vessels, costing one-fourth or one-fifth as much?

It is true that a Chicago might be able to avoid a more powerful enemy, but her principal object would be the destruction of merchant vessels, and she would be as liable to meet a more powerful enemy that she could not avoid, as would five smaller vessels in pursuit of the same object. From her passenger and mail-carrying merchant fleet, England could turn out a fleet of cruisers swifter and more powerfully armed than the Chicago or Boston, and we could do the same with such a fleet; but of that anon.

One of the strongest arguments in favor of the smaller vessels is, that after the first stages of war, neither they nor the Chicago would be in great demand at sea, and that the former might then be utilized on the Lakes, while the latter could not.

I do not like to advocate the smaller vessels, because a small ship, at best, is a poor representative of power; moreover, it can be built at short notice in emergency; but, if it is needed to perform certain peace duties, and if it occupies an important place in our scheme of preparation for war, it is undoubtedly the exponent of our necessities in the interest of economy.

Those subordinate peace duties in the performance of which we are most actively engaged at present, require the presence on foreign stations, and in our home ports, of handy vessels of light draught and moderate power; and when we consider in connection with this, that such vessels could perform the functions of "commerce-destroyers" on the outbreak of war, that they could afterwards be useful in our rivers and on the Great Lakes, and, furthermore, that *the economy effected by them would conduce to the more efficient development of our war power in the construction of our first-class battle-ships and coast-defenders, our main dependence in time of war*, I think we are justified in concluding that the chief characteristics of the vessels entrusted with the duty of "intercepting the enemy's food and industrial supplies," may be regarded, as follows:

TYPE III.

1. Seaworthiness,	
2. Habitability,	
3. Light Draught,	Selected with reference to the greatest depth (say 10 feet) that could be carried through our canal system to the Great Lakes.*
4. Moderate Speed,	Not *less* than 10 knots.
5. Endurance,	Selected with due regard to the assistance of sail-power at sea.
6. Handiness,	
7. Moderate Offensive Power,	Say, One 5-in., or 6-in., B. L. R.; Four Rapid-Firing 6-pdr. Shell-Guns; Two Revolving Cannon; Bow and Stern Torpedoes.
8. Moderate Defensive Power,	Small size and the judicious arrangement of decks and coal bunkers would afford a protection adequate to the offensive power of these vessels.†

It is a popular impression among some foreign naval authorities, that future fleets will operate in much the same manner as an army on land, with their skirmishers, cavalry, heavy artillery, and light infantry. The "cavalry of the seas" is a choice expression, but it requires sound theories to give it force. A fleet composed of an incongruous mixture of vessels, possessing varied qualities of seaworthiness, speed and power, supposed to represent the mobility of an army, would labor under peculiar disadvantages of the elements on the high seas; and an attempt by the different branches to exercise the functions assigned them would result in a weak incoherency. Such a fleet could be easily destroyed in detail by a few "battle ships," which would represent a concentration of power and an independence of action not possessed by the combined branches of the large "sea army" pictured in the imagination of its advocates.

For extensive operations against an enemy's coast or island bases, the vessels of Types I and II would perhaps require the assistance of army *transports* and *supply vessels*, for which we could depend upon our merchant marine, since these would not be required during the first stages of the war; but the possession of battle-ships would

* This draught is not necessarily the load draught of the vessel.

† It should be noted that the sail-power of these vessels could be abandoned on their arrival in the United States, and that the weight thus saved could be utilized in strengthening their offensive and defensive powers after their arrival on the Lakes.

enable us to transport a small army without the aid of other transport vessels.*

In regard to the transmission of messages during war it is well to note [see map] the advantages possessed by England in the position of our principal Atlantic cables, two of which could not be tapped, during war with that power, since they belong to France and connect French territory ; on the other hand, it would be possible for us, by means of either these or the South American lines, to communicate with any nation, provided we were at war with no two powers at once. In this connection it is also well to bear in mind that it is possible for foreign powers to find convenient *allies* among many of our weaker neighbors, in the event of war with us.

England is neither our only neighbor, nor the only power with whom we are liable to be at war. We cannot allude to the "Virginius affair," or the attitude of Spain towards us at various times, without feelings of humiliation. In the event of war with that power, our principal operations would be confined to protecting our seaboard cities, and to seizing his only important base near our territory. A portion of our vessels of Type I should be available to assemble quickly at Key West, and these, together with a few of Type II and a few transports and supply vessels from the merchant marine, would form a formidable attacking fleet against Cuba. In a war with France, the same sort of a fleet could operate successfully against and hold her bases at the mouth of the St. Lawrence and in the West Indies; but more attention would be paid to the defence of the coast. In our present condition, Brazil, Chili, or the Argentine Republic might send a fleet of ironclads to devastate our seaport cities ; but although the operation would be humiliating to us, the results would scarcely justify so bold an operation at such great distances from their bases, *unless* they were coöperating as allies with some other power. In retaliation for indignities on the part of those nations, if we were prepared, a blockade and bombardment of their coasts could be readily performed by vessels of Type II. Operations against the Argentines

* *Number of Merchant Vessels available for Transportation, at present.*

		Capacity.	
No. of Ships.	Net Tonnage.	No. of Men.	No. of Horses.
(*a*) ATLANTIC.			
87	95,000	45,000	15,000
(*b*) PACIFIC.			
22	35,000	15,000	5000

and Brazilians, however, would require in addition a few of Type I, on account of the shallow harbors of those countries.

The same general disposition of vessels for defence could be adopted in the event of war with Germany. For offensive measures against that country the most effective vessels to use against the ports of the North Sea and the Baltic would be those of Type I. But those vessels could not operate far from their bases, and it is well to notice just here the adaptability of the ships of Type II to supply the need of *bases*, at once powerful and mobile, to those of Type I, when the latter are required for service at a distance from the United States. The battle-ships could most effectively convoy the more sluggish but powerful ironclads to the seat of war and furnish them constantly with fuel, ammunition, guns, men, and all kinds of necessary supplies, while performing other important functions. The transfer of supplies could be made either on the open sea, in bays or channels, or possibly in neutral ports. Thus the outer line of blockade and the transport of munitions of war between the United States and the seat of operations could be safely entrusted to the powerful, independent, and rapid battle-ships of Type II.

Enough has been said to conclude that in reconstructing our Navy with the object of defence against England, it would be adapted to command respect and observation of our national rights from any other power with which we are likely to be at war.

V.

Can the types that we have selected for our war nucleus serve our "peace requirements," and if so, how?

The vessels of TYPE I would not be useful as cruising ships, and in order that they might be retained in a constant state of efficiency they should be kept either in fresh water basins, or lifted out of the water and stored along a convenient water front—on gridiron docks, similar to those in use by Russia—near their bases of operation, at which places our principal dockyards or naval stations should be situated. For the same reason, and to satisfy the third condition of our peace requirements, officers and men should be given opportunities for handling them occasionally. Suppose, for instance, at a certain time every year, preferably in the autumn, a detail of officers and men, either from the North Atlantic Squadron or from the training and receiving ships, were required to man one or two of those vessels, and take them out into

the open roads, for exercises in manœuvring and target practice, and after an experience of a week or more, to replace the vessels and stores in the condition in which found. All the details would be pre-arranged by the officers notified to hold themselves in readiness, and the fitting out and exercising of two vessels in the same harbor, under the eyes of the commanding officer of the North Atlantic fleet, would stimulate a spirit of rivalry which would be highly beneficial to the personnel in many ways. The principal benefit, however, to be derived from the scheme, would be the assurance that these vessels could be got ready at very short notice at the outbreak of war; that their good or bad condition and qualities would become known, and their defects remedied, and that the officers would know how to use them advantageously when war required their use in earnest. If different vessels were thus fitted out each year for a short season of evolutions, the whole ironclad fleet would serve the principal objects of a "peace navy," and at the same time be maintained in an efficient condition. Reports on the results of these exercises, and suggestions by those in command, would be retained at the department as a guide to their efficiency, and the whole manœuvre could be cheerfully performed with manifest benefit to the service, and no additional expense to the government.

One vessel of TYPE II, on each of our cruising stations, would be a fitting flagship to maintain the prestige of our flag abroad; would form our best school for the training and discipline of officers and men; would carry men and officers enough to form efficient landing parties for the protection of American citizens at home and abroad; would serve as a comfortable transport for conveying distressed citizens from threatened danger, in irresponsible belligerent communities; would be ready at all times, and in all states of the weather, to transport her power with celerity to any point in the interests of humanity; would be the most efficient possible aid in enforcing the laws of neutrality, and would be ready to repair with celerity and certainty, to her proper war station on the declaration of war, with a complement large enough for manning captured prizes *en route*.

TYPE III possesses the advantage of adding to a moderate efficiency in the performance of all the duties of Type II, the important qualifications for assisting the cause of scientific investigation, and executing surveys in an economical manner. But the advantages of this type are most apparent when we regard it as an essential part of the cruising fleet, of which the flagship is the central power or base on a

foreign station, because through it Type II has the ability to extend its power into shallow waters, or to spread that power in many different directions at the same time.

It will be apparent that the personnel serving on the gunboat class, during a whole cruise, would be deprived, for the time being, of the benefits of experience at the heavy guns and in other duties incident only to the interior economy of the larger vessels, and that, on the other hand, those serving on the battle-ships, of which the sail-power should be strictly auxiliary, would be deprived of the more active experience incident to handling a small ship under both steam and sail. In order to divide the hard work and vary the monotony of a cruise, to extend experience and create a healthy spirit of rivalry among all in the performance of duty, it might be a good plan to institute a system of yearly transfers of complements between the flagship and the gunboats. This would extend the sphere of experience in exercising various responsibilities, and stimulate that interest in the service which is so necessary to the maintenance of an efficient and economic personnel.

VI.

It appears, then, that the nucleus of our war power could perform the offices of a "peace navy" in the best interests of efficiency, and that in establishing a reconstruction policy, *no ship should be built which does not designedly occupy her place in the great scheme of preparation for war for national defence.*

No demonstration is necessary to prove that our naval force must be stronger during war than during peace, but it is not a struggle of endurance, such as that of our last war, for which we shall need to be prepared. It is not probable that naval wars will again run the length of many years, because those ships which will form the main defence of a country cannot be built in a few months, and the country best prepared at the opening of hostilities will be in a condition to strike sudden decisive blows, and thus prevent the expansion of war power by that nation most neglectful of its defences and maritime interests. Superiority in numbers, however, does not necessarily indicate superiority in preparation. The power possessing a few vessels adapted to the necessities of the age at the period of the war, will possess a superiority that will far outweigh the advantages of a

numerous fleet composed of obsolete vessels. If, then, it is not possible or even necessary for us to possess a very large fleet, great care and sagacity is required to maintain the fleet we do possess, in a condition thoroughly adapted to the requirements of war, so that it may be efficient when required for use.

It is a popular idea in this country that the best policy to pursue in naval construction is to watch the progress of other nations more actively engaged, and when occasion requires, to apply the results of their experience in building our vessels; and the advocates of this method claim that it saves the expense of experiment. Our first duty is undoubtedly to watch the progress of other nations and to benefit by their experience, but the experiments we accept second-hand may turn out failures, and we should exercise great caution lest we be drawn into mistakes. If we are not to maintain a large navy, we cannot afford to stake our success in making it efficient on the soundness of their judgment, and we should therefore guard against being dependent on them, not only for material and manufacturing skill, but for ideas or originality. If we encourage, foster, and reward our boasted American inventive genius, we shall find no difficulty in the development of sound principles on which to base our calculations for the future. If we are not yet able to trace the "curve of progress" in naval science, it is important that we should establish a system, in our plan for reconstruction, by which we may be able to settle the problems on which a clear understanding of its difficult equation depends. The *basis* of such a system may be expressed by the following principle: *No ship should be built that is not superior, or at least fully equal, to those of any other nation, of the same type, contemporary with it.*

In the modern science of naval warfare there is a broad field for the exercise of inventive genius which, owing to our present neglectful policy, is closed for the want of encouragement. In fact, the proper expansion of our war power at the critical moment, as well as the efficiency of our preparations, depend on our cultivation of this genius for purposes of national defence; and if we could open a broad field of fair competition to the civil and professional talent of the land, the public interest would be aroused and a large portion of the people gradually educated up to the standard required for the execution of any policy that might be demanded by our peculiar situation; moreover, such encouragement would stimulate the increase of national wealth and prosperity, and the public purse-strings would not be

drawn so tightly as now, against the support of an arm of defence so essential for the vigorous growth to which I have alluded in the first part of this essay.

Therefore, in order to facilitate the execution of a progressive policy, I would recommend some such scheme as the establishment of an *annual experimental fund* under the control of the Advisory Board, which could not be used for any other purpose than the trial of inventions and the reward of successful competitors. A prize of sufficient value to reward the best talent, on subjects of importance to the service, might be offered for competition each year; a systematic and thorough test of all such productions deemed worthy of it by the Advisory Board might be inaugurated, and the trials might be performed under the direction of the Bureau most interested. The money so expended would be the means of a great saving to the government, from the fact that the finished constructions would become less and less experimental in character, and it would decrease the range of doubtful investigation. Many problems are still unsettled, such as:

The most convenient arrangement of bulkheads, decks and cells, to combine the greatest protection with economy of space in arrangement of cables, stores, etc.

The best arrangement of compartments for diminishing the effect of shell explosion within a ship, and for neutralizing the effect of, or arresting the entrance of water through shot-holes.

The best form of vessel and best disposition of weights to combine a *level* with a *steady* platform, without sacrificing *safety*, endurance and speed.

The best type of engines and boilers, combining high speed with compactness, light weight, durability, capacity for repair, and economy of fuel at either high or low speeds.

The best fuel suitable for war purposes, and the best means of carrying it.*

The best form of propelling power suitable to the needs of war ships.†

* Here is a vast and important field just now, owing to the good results obtained from liquid fuels and hydrocarbons of various characters. The successful use of naphtha in combination with steam on certain American locomotives, and the success of the Russians in the use of petroleum as fuel on board of steamers, show that there is ample room for investigation.

† It seems to me that the hydraulic propeller would be a theoretically perfect power for some ships, and in view of the success of late results in Germany and England, I look forward to its adoption in the near future.

The best full rig for small sea-going steamers, and the best auxiliary rig for large steamers, combining strength, simplicity, lightness, and adaptability for quick handling in reducing to fighting trim.

The best disposition of armor combining least weight with greatest resisting power.

The best method of mounting guns to combine all-around fire with facility for working under given conditions.

The best quality of metal or combination of metals suitable for ship construction.*

The best projectiles, combining penetrating power with capacity for bursting charge, and the best mobile torpedoes, combining power, range, accuracy, and simplicity.

There are innumerable details in the development of which it is desirable to interest the inventive and scientific skill of our people, both civil and professional; the application of electricity, for instance, as an aid in almost every branch of naval science, offers a wide field for investigation; and if the value of a new theory in any of its various ramifications is demonstrated, it is paramount to our interest that we be the first, if possible, to take advantage of it. If we were in the van of progress and inventive skill it would do quite as much for our *prestige* abroad as the actual possession of a large fleet.

It would be a great step towards economy if we were to establish, at the Washington yard or other suitable place, a model-tank and outfit, such as that so successfully used by the late Mr. Froude in England. Experiments could be efficiently conducted by experts from our own construction corps, with great advantage to the efficiency of that branch of our personnel and with great economy to our shipping interests.

In testing the efficiency of a new innovation, such as would require the construction of a complete vessel, the experiment might first be made with a small one in view of eventually adding that vessel to our gunboat fleet, if successful.

VII.

Owing to the constant progress of naval science, it is highly injurious to economy in ship-construction to delay building for long

* Although we are on the eve of *steel* construction we should provide against being behind other nations in the adoption of manganese-bronze or any other metal which may prove better adapted to naval use in the future. Large torpedo boats, Whitehead torpedoes, and air-chambers for those torpedoes are already being made of manganese-bronze with excellent results in Germany.

periods: (1) because ships rapidly deteriorate if neglected in this state; (2) because they eventually cost more than their original estimates, owing to constant alterations in their designs and the expense of preserving them in a semi-complete state; (3) because when finally completed, they do not meet the requirements of the age, and are almost, if not quite, obsolete in type.*

One of the most important reasons why we should build the most efficient vessels only, is that the greatest expense to be met in providing for the wants of a navy cannot be devoted to new constructions; and this fact ought to be very forcible with us, on account of our past lack of success in the administration of naval affairs. A large proportion of the money is absorbed in *maintenance and repairs*, and this proportion increases in inverse ratio to the worth or efficiency of the fleet. In other words, if we now possess a new fleet quite up to the necessities of the day, twenty years hence that fleet will be less efficient and at the same time cost more to maintain than it does now. It is necessary, then, in order to economize in the end, that all new constructions should be built of the most suitable material in use at the time of their building, and that no vessel should be retained on the list longer than the average efficient life of a war-ship constructed of that material. If we have wooden vessels on the stocks, in a state of semi-completion, it would be more economical in the end to sell them now, than to complete them for a life of semi-impotency, and as a fruitful source for absorbing a large part of our appropriations in future maintenance. The great secret in naval economy which many nations have yet to learn, is *to maintain nothing superfluous or inefficient*, and this fact should possess greater force with us now in the construction of new wooden ships of an obsolete type, than it would twenty years hence in the maintenance of an inefficient fleet which may now be efficient.

The most essential part of any plan for the reconstruction and increase of our navy, is the adoption of a carefully considered building programme, and the establishment of a sinking fund or credit.

If we know the number of vessels needed, their cost and the time to be allowed in building them, we can determine the average yearly or normal expenditure on which to base our programme. This normal expenditure is what would have to be appropriated if

* I need only refer to our experiences with various wooden ships, and with monitors recently launched.

the same amount of war power were added each year; but as the construction of a new fleet is an experience which we have not enjoyed for some time, and as we are naturally doubtful concerning the quality of those we could turn out at first, it would evidently be impolitic to expend the same amount during the first years as during the last. In other words, our programme also should be accumulative or progressive in character. To ensure the future efficiency of our peace-footing after the lapse of the time allowed, it will be necessary to provide for the continual addition of new constructions to replace vessels whose efficiency will gradually disappear as they approach the limit of useful age; but it will be time enough then to revise the programme we now establish, and provide for the continuance of a fixed policy, a steady addition of new and efficient vessels, and a similar sale of those that have passed their ages of usefulness and have begun to absorb large doses of "maintenance."

The establishment of a sinking fund is necessary, to set the wheels of progress in motion, or to develop those industries on which we must depend for the finished ships, if not for the raw materials. It may be impossible to determine the exact cost of the completed fleet, because the later productions ought to cost less than the first, owing to the increased building facilities which will be produced; but the cost may be estimated approximately, and Congress should establish a sinking fund for that amount in the National Treasury, with the proviso that it could be touched for no other purpose than the construction of *new* vessels. By this act the iron producers and steel workers, supplying ship-building establishments, would be persuaded to increase the productive facilities of their establishments, the demand for skilled labor would be increased, and we would become exporters of much that is superior to what we now import.

It is desirable in reconstructing our navy to do it in such a manner as to encourage the development of our much neglected merchant marine; in fact, the reconstruction of the navy can be made to go hand-in-hand with that of the merchant marine, with mutual advantage. It is painfully evident that if we were to commence the construction of these new ships at our navy-yards, we should have to deprive our private builders of many of their skilled laborers, and would thus impede the building of a merchant fleet. Building in steel or iron would be a new industry at our navy-yards, and new plants would be required; besides, we are still unsettled, and apt to remain

so for a while, as to the future location of these yards, and it would be folly to start a plant at a yard which might be sold a few years hence. On the other hand, if we begin our construction at private yards, we shall have ample experience and material to draw from, after the inauguration of our building policy has had an opportunity to expand the facilities for doing so. If our yards were in successful operation now, there would be no question about the quality of the work they might turn out, and the cost ought to be nearly the same in both cases; but in their present unsettled condition we shall have enough to do to decide on the most suitable sites, and to establish a systematic arrangement of docks and store-houses sufficient to provide for the future maintenance and repair of our new fleet. Furthermore, there is not the pressing need of encouragement at our yards that is experienced by our private builders, upon whom we shall have to depend, as most governments do, for the expansion of our war power on the outbreak of a war. Our private building establishments need encouragement in order that their *number* may be increased, because on their number, more than on their capacity, within large limits, depends our power of expanding in time of war. It would be more difficult for an enemy to destroy a number of private yards of moderate capacity than one of great capacity, provided the majority of those yards were situated in or near the same basins, as is now the case, so that the same system of concentrated defence would suffice to protect them all. If the contracts were open to all bidders, the *cost* would be maintained within reasonable limits; and if the ships were built under the scrutiny of government inspecting officers, the work would be as thoroughly done as if performed under the supervision of the same inspectors at government yards. As regards the rig and equipment, however, there is a uniformity required which could best be maintained by having that work performed at our yards, where we already have ample facilities and skill for that purpose.

The "experimental fund," before mentioned, would secure the advantages of civil inventive genius in influencing the character of the designs, all of which should be made at the Navy Department, subject, however, to criticism by private authorities, and revision, if deemed advisable.

These remarks do not apply strictly to the construction of *guns*. The art of gun-construction in this country, owing to our long neglect, is again almost in its infancy; so far behind in the race of

progress is it, that nothing less than a great effort on the part of the government will again enable our private gun-founders to compete in the markets of the world, or our guns to become known for their excellence and superiority. Competition is the life of gun-construction, as demonstrated in Europe, because the demands of the individual governments in which gun-firms are situated are not alone sufficient to stimulate the production, and rivalry among competing firms for the outside market develops the excellence of their work. We could, doubtless, establish a national gun-foundry in this country that would turn out guns as good as any in Europe, but we could not hope to maintain such an establishment with a productive capacity equal to that which the private firms of the country are capable of developing. There is a subtle and important reason, however, why we should turn our attention particularly towards developing private enterprise in this direction. If other governments patronize our private firms—and the trade is enormous among the unproductive powers—we have a prime assistance in defence against their aggression, for in time of war their supply would be cut off, and ours correspondingly increased. If at such a time they could depend on a powerful ally for their gun supply, the guns would be different from the ones they had been accustomed to, and difficulty would be experienced in using them. We can readily imagine the advantage we should possess, in event of war with France, by having the firm of our countryman Hotchkiss situated in the United States instead of at St. Denis.

The sinking fund which I have mentioned with reference to the construction of ships might include the cost of armament, but we could not rely on this sum to set the wheels of private gun-construction in motion. A new and expensive plant would be required, and the reward to be obtained would not pay for the investment. If several firms were started, and the contracts were allotted to the lowest bidder, all but one would fail. Although it is desirable to have several gun-firms situated in different parts of the country, the success of more than one would be problematical; but it is highly probable that one complete and well-appointed establishment supplied from the immense resources of this country, would be enabled, with the proper encouragement, to rival in the world's market the best of those in Europe. Our best policy, therefore, is to foster a complete establishment on a large scale, similar to that of Krupp in Germany, or of Armstrong in England; and we can never expect to attain this desirable end without inaugurating some well-concerted

plan, the success of which must be assured by the latent value of the public funds.

By establishing a public loan we could find reliable and competent gun-makers enough to form a Consolidated Association, and to establish a well-organized system, capable of indefinite expansion, and modelled somewhat after the remarkable plan of Herr Krupp at Essen. The loan would eventually revert to the coffers of the Treasury with interest, but the plans of the works and details of construction, at least until the loan were paid off, should be subject to government approval, and the government should reserve the right to representation by its officers in the direction of affairs. The right to control the establishment as a national gun-foundry, under certain just restrictions, in connection with the right to representation, would secure the government against any difficulty in the payment of bonds. The land for the site would be willingly ceded by the State in which it would be located, and the United States would become simply a stockholder for a reasonable length of time, in a firm the success of which would be assured. The locality should be selected with due regard to facility for obtaining raw materials, and transportation to the three seaboards and the Great Lakes. It should also be out of reach of an enemy's ships if possible, and I know of no better site than the vicinity of Pittsburgh, Penn., where we already have a national arsenal, and a foundry that once supplied us with excellent guns. There is no doubt about our ability to manufacture suitable guns at the Washington Navy Yard, but the facilities of that yard would have to be vastly increased to meet the demands of the government, and the yard itself would suit our necessities best if retained principally as a naval arsenal and experimental station.

VIII.

The cost of maintenance and repairs is everywhere very serious. In Germany and Russia, where service is compulsory, the amount devoted to new constructions is 66 and 62 per cent. respectively of the entire cost of the navy. In England and France, however, this percentage averages, respectively, 36 and 35 per cent. In our estimates for the year ending June, 1885, the estimated cost of increase is 28 per cent. of the total; but if we exclude from the cost of maintenance that estimated for "repairs and preservation of vessels" and that for "steam machinery," the percentage becomes 32. The Germans and Russians do not utilize many of their

vessels for cruising purposes, and the amount of work done by them may be regarded in the light of an insurance on the national safety, pure and simple; but the economy of their administration, particularly that of the Germans, is due, in a great measure, to the systematic methods adopted by them. The German Navy is comparatively new, and consequently not bound down by old traditions established in an age when the requirements of naval warfare were very different from what they are now-a-days. If we constantly repair old vessels and make them move about under the name of men-of-war, they compromise rather than maintain the prestige of our flag; but one of the worst evils arising from the practice is that the longer these old vessels are maintained, the more numerous are the changes required to give them a semblance of efficiency, so that the cost of repairs increases with age, in a sort of geometrical ratio.*

*** Statement showing date of construction, original cost, and repairs under the Bureaus of Construction and Repair, Steam Engineering, and Equipment and Recruiting, of a few vessels borne on the Navy Register, November, 1883 [*vide* Senate Ex. Doc. No. 48, Forty-Eighth Congress, First Session].**

Name of Vessel.	Displacement Tonnage.	Date of Construction.	Original Cost.	Repairs Since.	Total.	Percentage of total cost absorbed by repairs.	Remarks.
Powhatan.....	3980	1848	$ 771,771.00	$ 1,199,574.81	$1,971,345.81	.61	Paddle wheel str.
Lancaster.....	3250	1858	670,081.00	1,657,210.66	2,327,291.66	.71	
Brooklyn......	3000	1858	417,921.00	1,591,716 83	2,009,637.83	.79	
Pensacola....	3000	1862	773,573.02	1,796,521.51	2,570,094.53	.70	
Hartford......	2900	1858	502,650.00	1,520,770.89	2,023,420.89	.75	
Richmond....	2700	1858	566,259.00	1,293,228.45	1,859,487.45	.69	
Lackawanna.	2220	1862	523,392.19	1,210,558.15	1,733,950.34	.70	
Juniata........	1900	1862	364,820.00	1,158,133.10	1,522,953.10	.76	
Ossipee.......	1900	1861	407,064.20	1,197,391.39	1,604,455.59	.74	Exclusive of recent repairs.
Iroquois	1575	1858	307,155.00	1,104,844.17	1,411,999.17	.78	
Kearsarge....	1550	1861	286,918.00	1,123,415.75	1,410,333.75	.80	
Grand Total of 92 vessels borne on the Navy Register, Nov., 1883, including ships in commission, in ordinary, unfinished or on the stocks, ironclads, sailing ships, hulks, and tugs..........			$40,796,612.92	$41,200,822.13	$81,997,435.05	.50	

All of the vessels cited in the foregoing list are in cruising condition and entrusted with the prestige of our flag abroad, yet not one of them can be regarded as an efficient fighting ship of the day; but if they teach us to correct our past folly, the money thus expended may eventually be looked upon in the light of an economical investment.

If, therefore, we sell our inefficient wooden vessels as rapidly as they are replaced by new constructions, beginning, of course, with the oldest and most inefficient, we shall lose nothing of intrinsic value, but shall gain much in point of economy, because at the time of sale they will still be of value to the merchant marine, and will command prices somewhat commensurate with their original cost, while, a few years later, their value will be reduced to that of so much old hulk or machinery.

When ships are allowed to remain idle or "in ordinary," after returning from a cruise, they rapidly deteriorate, and when they finally become obsolete in design they have not seen sufficient service to be regarded as economical investments. But by keeping all of our peace footing in constant repair and actively employed throughout their lives of naval efficiency, we would require the least number of vessels and would get the most work out of each. And if at the expiration of this period (presumably twenty years, the average age of efficiency in a war-ship) the proceeds of their sale were available for the repair of newer vessels, the cost of repairs would be kept at its lowest figure.

After our reconstruction is completed, if we establish a fixed policy of replacing old vessels by new yearly, it might become possible to devote more than 30 per cent. of the annual appropriations to new constructions.

The following tables are estimated with due regard to economy, and are intended to represent the least necessities of our situation:

VESSELS REQUIRED.

TYPE I.

For the Defence of	Class (a).	Class (b).
The New England Basin (Cape Cod to Passamaquoddy Bay),	2	
The New York Basin (New York to Cape Cod),	2	
The Delaware Basin (Delaware Bay and River),	1	1
The Chesapeake Basin (Chesapeake Bay and Tributaries),	1	1
The Carolina Basin (Cape Henry to Key West),		3
The Gulf Basin (Key West to Texas),		3
The Lake Coast (with headquarters on the Mississippi),		2
The Pacific Coast (headquarters at Mare Island),	2	
Total,	8	10

The four double-turret monitors which are to be completed might be substituted as follows:

On Chesapeake Bay, to replace, ...		1
On Delaware Bay, "		1
On Carolina Basin, "		1
On Pacific Coast, "	1	
Leaving for new constructions, .	7	7

TORPEDO BOATS:

For use on Lakes, headquarters at Newport, for instruction of officers and apprentices, ...	10
For use on Atlantic Seaboard, headquarters at Annapolis, for instructional purposes, ...	10
Total, ...	20

TYPES II AND III.

Stations.	Battle Ships II.	Gunboats III.
Asiatic Fleet, ...	1	10
Pacific Fleet, ...	1	10
European Squadron, ...	1	6
South Atlantic Squadron, ...	1	4
North Atlantic Fleet, ...	2	8
On Atlantic Seaboard, building or fitting out to replace returning Cruisers, ...	2	6
On Pacific Seaboard, building or fitting out to replace returning Cruisers, ...	1	4
Total peace footing, . .	9	38
To be utilized on the outbreak of war:		
On North Atlantic, ...	7	30
On North Pacific, ...	2	
On Great Lakes or Rivers: First stages of war, .		8
On Great Lakes or Rivers: Last stages of war, .		38

Type.	Number.	Est. Displacement!	Est. Cost per Vessel.	Total Cost.
I. (class *a*)	7	6,000 tons	$2,000,000	$14,000,000
I. (class *b*)	7	1,500 to 2,000 tons	600,000	4,200,000
II.	9	11,000 tons	3,500,000	31,500,000
III.	38	800 tons	300,000	11,400,000
1-c. Torpedo boats	20	50 tons	38,000	760,000
			Grand total,	$61,860,000
			Say	$62,000,000*

* The revenue receipts, estimated on the basis of existing law for the *single year* ending June 30, 1885, will exceed by $60,000,000 the ordinary expenditures, including the amount devoted to the sinking fund. *Vide* President's Message.

Unless we were threatened with war in the *near* future, it would be bad policy to lay down the plans of the battle-ships at the rate of more than one a year, because we wish each one to embody some improvement over its predecessor; and as we require nine of them, *ten* years seems to be about the least limit of time that should be allowed for the reconstruction of our fleet.

The construction of the coast defence ironclads should also be undertaken in a progressive sort of way, because of so many novelties in design; but there is no great demand for care in commencing to build the gunboats, and by building the greatest number at first, we should be enabled still to balance the yearly estimates, and at the same time to replace old vessels more rapidly.

"Sinking Fund," Total expenditure for 10 years, $62,000,000.
Average expenditure in 1 year, 6,200,000.

If this average expenditure be regarded as 30 per cent., the total yearly expenditure, including "cost of maintenance and repairs," would be $20,666,666, not a very great increase over our average annual expenditure from 1867 to 1877, which was $20,188,730.

This yearly expenditure is only 34 per cent. of what, in the year ending June 5, 1885, will be the annual surplus in the treasury, and 17 per cent. of what was voted recently for pensions, one of the results of previous neglect in matters of national defence.

The following outline illustrates the building programme:

	First Year.	
18 Gunboats, ...	$5,400,000	
10 Torpedo boats, ...	380,000	
	$5,780,000	$5,780,000
	Second Year.	
10 Gunboats, ...	$3,000,000	
10 Torpedo boats, ...	380,000	
1 Ironclad (class *a*), . . .	2,000,000	
1 Ironclad (class *b*), . . .	600,000	
	$5,980,000	$5,980,000
	Third Year.	
4 Gunboats, ...	$1,200,000	
2 Ironclads (class *b*), . . .	1,200,000	
1 Battle Ship, ...	3,500,000	
	$5,900,000	$5,900,000

Fourth Year.

2 Gunboats, ...	$600,000	
1 Battle Ship, ...	3,500,000	
3 Ironclads (class *b*), . . .	1,800,000	
	$5,900,000	$5,900,000

Fifth Year.

2 Gunboats, ...	$600,000	
1 Battle Ship, ...	3,500,000	
1 Ironclad (class *a*), . . .	2,000,000	
	$6,100,000	$6,100,000

Sixth Year.

2 Gunboats, ...	$600,000	
1 Battle Ship, ...	3,500,000	
1 Ironclad (class *a*), . . .	2,000,000	
	$6,100,000	$6,100,000

Seventh Year.

1 Battle Ship, ...	$3,500,000	
1 Ironclad (class *a*), . . .	2,000,000	
1 Ironclad (class *b*), . . .	600,000	
	$6,100,000	$6,100,000

Eighth Year.

1 Battle Ship, ...	$3,500,000	
2 Ironclads (class *a*), . . .	4,000,000	
	$7,500,000	$7,500,000

Ninth and Tenth Years.

1 Battle Ship, ...	$3,500,000	
1 Ironclad (class *a*), . . .	2,000,000	
1 Battle Ship, ...	3,500,000	
1 Battle Ship, ...	3,500,000	
	$12,500,000	$12,500,000

In this way the greatest *number* of ships would be built during the first two years of the programme.

Allowing a complement of 500 men to each of the battle-ships,

either cruising or fitting out, and 70 men to each of the gunboats, either cruising or fitting out, we have,

9 Battle Ships, . .	4500 men,	477 officers.
38 Gunboats, . .	2660 men,	570 officers.
Total,	7160 men,	947 officers.
No. of men allowed at present,	7500	

Leaving 340 men to be utilized elsewhere, and without taking into account the 2500 marines and 700 apprentices allowed.

IX.

While the construction of our new fleet is in progress, the question of dockyards and naval stations should be carefully settled, in order that docking, repairing and maintenance could be economically and thoroughly performed entirely by the government, and that the government might be enabled eventually to build at least a portion of its own ships, and thus to increase the building facilities of the country beyond the capacity of the private yards, which would then be fully established in good working order. If our most important dockyards are to be sold, the sites for new yards should be wisely selected with a view to avoiding in future the causes that now demand their sale. It is undoubtedly advantageous to have them near our important seaboard cites, because one system of defence is then sufficient to protect both city and dockyard; but they should be situated at such distances as to be outside the future growth of those cities. It is advantageous to have them near the building centres, where the cost of transportation of material would not be great. They should also be situated in deep bays, inlets or rivers, the defence of which could be made as independent of ships as possible, and at such distance from the sea that bombardment by attacking vessels outside the range of land defences would be impossible. They should also be approachable by deep draught ships, and their sites should command extensive water-fronts for the construction of dry-docks and basins or gridiron ways. Their approaches also should be open at all seasons of the year.

But the most important consideration is that the sites should be selected with a view to enhancing their strategic value in time of war, and one first-class dockyard on the Atlantic coast and one on the

Pacific coast would be amply sufficient. Although we have a number of good sites on the Atlantic seaboard, those of our present yards are all objectionable; that at Portsmouth would be difficult to defend, and the climate is severe in winter; that at Boston is too near the city and is open to the same objection; that at New York is being looked upon with wistful eyes in the interests of trade, and is also within range of the heavy ordnance of ships below Coney Island; that at Philadelphia satisfies nearly all the requirements, but in the near future may be sacrificed to the business interests of Philadelphia and the Pennsylvania Railroad; that at Norfolk is too small for a first-class yard, its water front and approaches are cramped, and it is rather too far removed from the building centres. The nearest approach to a perfect site is at some point near the head of Chesapeake Bay, from which there is canal communication direct to our great building and shipping centres, Wilmington, Chester, Philadelphia and New York. There might be difficulties which are not apparent at present, but the situation of a first-class dockyard somewhere near Baltimore presents so many strategic advantages that it is worthy of investigation.*

On the Pacific side there is apparently but one locality, the Bay of San Francisco, which possesses all the desirable features. There are many difficulties encountered at Mare Island as it is now laid out; but it should be remembered that its facilities could be extended to the side facing San Pablo Bay, by the erection of the proper sea walls, docks, basins and breakwaters.

The first-class *dockyards* should be devoted exclusively to the

* Four miles south of Baltimore, at a place where the land is sparsely settled, and which the growth of that city cannot reach, there is a site possessing topographic and hydrographic features remarkably suited to the establishment of a first-class dockyard on as large a scale as can well be desired. Its water front is formed by "Curtis Creek," the depth of which throughout a distance of 2½ miles is not less than 24 feet, and averages somewhat more. This creek is an arm of the Patapsco River, and its mouth forms a deep commodious basin about 1½ miles wide and 1½ miles long, beyond which the creek extends for 2¼ miles with an average width of about ¼ of a mile, and deep water near both shores. There are several capacious inlets, suitable for small craft, or the construction of docks and basins, extending from it to a short distance inland, and the straight channel leading to it is that leading to Baltimore harbor, dredged to 24 feet, which can readily be protected by land fortifications. Fort McHenry commands the inner approaches, and if placed in a proper defensive condition, together with suitable batteries on the lower headlands, might again, after some future crisis, proudly boast that "*Our Flag was still there.*"

building, docking, and repairing of ships, and the preservation or storage of coast-defence ironclads; and no naval ship in commission should be allowed to remain near them in times of peace, for the purpose of receiving slight repairs.

On the Gulf coast we need a *Naval Station* or depot for the preservation or storage of coast-defence ironclads, and for affording docking and supply facilities. Pensacola is badly exposed to bombardment, and the channel is not deep. Some point on the Mississippi River in the vicinity of New Orleans, if such could be found, would offer many advantages as a base for ironclads destined for the Lakes and for the Gulf coast. Other *Naval Stations* should also be maintained at Portsmouth, N. H., Boston, New York, Philadelphia, Norfolk, Va., and either Portland, Oregon, or Seattle Harbor, W. T., where the area of existing yards might be contracted to that sufficient only to maintain the docks, a few storehouses, and quarters for the small amount of personnel required to watch and care for them. The remaining land might be profitably sold, and the proceeds might defray the expenses of the new dockyard. In some cases parts of the land might be leased to private firms for the purpose of starting ship-building establishments, the government reserving the right of control or purchase of plant during war. If the docking and repair facilities of private firms on the Great Lakes are not adequate to meet the necessities of our light-draught ironclads and gunboats in time of war, a naval station should be maintained at each of the best ports on Lake Michigan and Lake Ontario.

Coal and supply *dépôts* should be scattered along the coast at such places as Eastport, Me.; Newport, R. I.; New London, Conn.; Port Royal, S. C.; Key West, Fla.; Pensacola, Fla.; Mobile, Ala.; and San Diego, Cal., where coal is not apt to be found in great abundance. Neither stations nor depots would require much space, and they could be maintained at small expense if all stores were carefully housed, and the cruising ship's personnel responsible for all work except docking. A small detachment of marines and workmen, with a few responsible officers, should be charged with their care and maintenance, and coal should be carefully housed, with proper ventilation, to prevent deterioration and theft.

X.

The cost of maintenance is so closely connected with measures of reform, that a reduction in the number of officers has of late come to be considered as almost the only resort. This delusive theory is apt

to lead to disastrous results with any nation, but should be particularly guarded against with us. Economy may be effected to the extent of getting rid of those who do not come up to the desired standard of efficiency, but to deprive the country of a large body of highly efficient trained officers ready to expand our war power at the outbreak of war, and to extend our influence throughout the scientific world during times of peace, is to take a step backwards towards fostering that lethargy in national development which I have endeavored to portray in the first pages of this essay.

The life of a successful naval officer is from necessity a life more of study than of work, and if a great reduction is made in the number of officers, many will be deprived of opportunities which they now possess for combining study with work which would have to be performed either by officers or by trained civil assistants, and the effect would be to narrow the officer's "sphere of usefulness," without in the end effecting any great economy.

But the worst feature, perhaps, about such a reduction is that it would deprive the country of an important class of developed resources which are necessary for national defence. Men and iron are both raw resources in a certain sense, and it is just as important that we should possess the power to develop trained seamen on the outbreak of war, as it is that we should possess the power to develop the ironclad or a fighting ship. It is one of the fundamental principles of our national policy that our commerce shall be one of our principal war resources, both in men and *materièl;* but of what avail will that resource be in a modern war, if we do not provide for maintaining the power to develop it quickly on the outbreak of war? This power, in the case of men, can be provided only by the quality and numerical strength of our trained officers, and the *quality* has never been found wanting. Doubtless we shall always be able to command brave men in the hour of danger; but bravery is not the only necessary quality in these days of progress; it must be combined with skill in the use of modern implements of warfare. Ships and men may be improvised to a certain extent, but not the officers or the skill necessary to do the improvising.

It may be noticed that I have neglected to provide for ships of the Boston and Chicago types, and it may be accounted for by the fact that I have been contemplating this reliance on the merchant marine to perform the duties of those types. If we take the proper steps for the development of our merchant marine, we may at the same

time provide for the building in that service of vessels fully adapted to perform the services of a Boston, a Chicago, or a Dolphin.

The development of our merchant marine, aside from its value as a war resource, would result in a great increase in wealth and prosperity, not only to shipowners and builders, but to those engaged in all other industries. The great value of the railroad in this respect is apparent, but the steamship line is a supplement to the railroad, and the increased facilities for the transport of mails, passengers, produce and heavy merchandise, possessed by the latter, would induce an increase of business which would benefit all industries similarly affected by the railroad. It is clear, then, that if we develop our merchant marine with a view to increasing our industries in time of peace, we should also develop it with a view to protecting those industries in time of war, and that the increase in wealth which would result from this development should justify some sacrifice of the funds of the national treasury.

It is not within the province of this essay to discuss the questions of "free trade" or "free ships," but there are one or two points that demand our attention. The first is, that if our shipbuilders should receive the encouragement proposed by the plan for reconstructing the Navy, they would be enabled to increase their capital, and, through it, the efficiency of their plant. Now, any increase in the efficiency of machinery to perform a certain amount of work would reduce the number of men otherwise required to perform it, and would *raise* correspondingly the standard of skill and the wages of the men employed. The profits to be derived from production under such circumstances would increase with an increased demand, and the cost of production would be constantly growing *less*, while the wages of skilled labor would be raised rather than lowered. Any attempt, therefore, on the part of the government to lower the price of ships, without corresponding aid or encouragement to builders, would tend to stifle home production, to lower the price of labor, and to discourage skill.

The second point is, that if we begin to depend on foreign-built ships for the increase of our merchant marine, we are sure to be supplied, for a while at least, with such as are wholly unsuitable for use in time of war, because insurance covers risk in the shipping of merchandise, and the cheapest ship, regardless of safety, is sure to make the largest profits and be in greatest demand.

In developing our merchant marine, then, the government should

take measures (1) *to increase the demand for ships and* (2) *to ensure their safety and efficiency.* The latter should be done whether free ships are admitted or not, and the only way to do it is either to impose certain *restrictions* on the quality of production, or to grant liberal *subsidies* for the production of good qualities. The *restriction* would still keep the price of ships up, and place the carrying trade in foreign hands, while the *subsidy* would at least give us good ships. Therefore, it is believed that after a revision of our navigation laws and a reduction of the numerous burdens imposed upon our commerce in the shape of fees and taxes, our best policy would be to grant subsidies to all steamers *in proportion to their efficiencies for war purposes.*

The efficiency of a steamer for war purposes might be made subject to an examination of her designs, and an inspection of her performance, by competent naval authorities under the Advisory Board. The standard of efficiency might be expressed by a formula such as the following:

$$\frac{S^3UP^2O^2W^2E}{DALT^4} = \text{Efficiency.}$$

Where S = Maximum Speed,
O = Offensive Power, or strength and capacity for mounting heavy guns,
P = Protection to vital parts, or defensive power,
E = Endurance, or fuel supply at maximum speed,
W = Seaworthiness and Safety or Stability,
U = Steadiness of platform,
L = Length of Ship or of "Tactical Diameter,"
D = Load Draught,
T = Time required for conversion,
A = Age in years or a certain term of years or fraction of years, as selected by authority.

By some such scheme as this we could not only provide speed and safety for our passengers and merchandise, and the resultant popularity and prosperity of our own lines in time of peace, but we would be able to develop efficiency for war purposes, to encourage or foster scientific investigation and inventive skill in naval architecture, and to diffuse a more general knowledge of naval requirements in shipbuilding among our civil population. Passenger steamers built under such encouragement could be quickly converted into powerful

battle-ships, and freight steamers could be made either self-protective against "Chicagos," or could be converted into efficient vessels of that type.

In steamers employed on the Great Lakes this is especially desirable, and would not conflict with our treaty in letter or in spirit. Merchant freight steamers, such as those possessed by England, are deficient in structural strength, and possess too small a margin of stability to be converted into efficient war ships; but there is much to be learned in the science of naval architecture, and the lessons to be derived from the trials of the "Livadia" point to a wide field for improvement in this direction.

From the numerous vessels of novel design proposed throughout the country, it appears that Yankee ingenuity is already at work on the problem, and it is to be hoped Congress will soon give the desired encouragement through some such scheme as here proposed.

XI.

There is one remarkable feature about our want of system in preparation for national defence which deserves at least a passing notice.

Vessels of the Revenue Marine require speed, seaworthiness, endurance, light or moderate draught, habitability, and a light armament; vessels of the Coast Survey and Fish Commission require moderate speed, strength, seaworthiness, handiness, habitability, and light draught, and are manned by naval officers and seamen.

The former would make efficient dispatch-boats and the latter efficient gunboats, without conflicting in the least with their peace efficiency, if their designs were subject to approval by, or under the control of, the Navy Department. They represent a certain amount of developed resources, and would contribute to the nation's strength in time of war, if maintained in an efficient condition with that end in view during peace.

These vessels may be employed on the Great Lakes in time of peace, where their services are greatly needed, without conflicting with the treaty of 1817.

XII.

The success of any plan for reconstruction depends upon our regarding the navy as established in time of peace with the primary object of being prepared for and efficient in war. Granting that the

reconstruction may be accomplished under our present form of administration, if we are to judge by experience and the lessons taught by our civil war, the continuance of a progressive policy in the remote future, and a readiness to commence active operations with the first notes of war, cannot be assured under a faulty central organization. The ultimate success of any department, civil or military, will depend in the long run, more on the peculiar fitness of the directing power, than on the efficiency of any of its branches. The Commander-in-Chief of a Navy, the Commander of a ship, and the Superintendant of a civil industry hold analogous positions in respect to the efficiency of the bodies which they control; a division of labor is required, and responsibility must be placed on those charged with the execution of particular duties; but at the same time a careful supervision and judicious direction by the heads of the respective establishments are necessary in order to ensure harmony and efficiency as a whole. If the head does not possess this directing power, or is subject to being influenced in the particular interests of one of the branches to the manifest detriment of the others, the harmony of the whole is destroyed and efficiency crushed.

It being one of the fundamental principles of our government that the "military element be under strict subordination to and governed by the civil power," it so happens that the head of our Naval Organization may be called upon to take command without any knowledge of naval affairs whatever; and unless the country can assure the appointment to this office of an intellectual prodigy every time a change occurs in the government administration, "strict subordination" and perfect harmony cannot be maintained.

The fact that the necessity for a division of labor exists, shows that in order to produce individual excellence, special knowledge is required in the efficient management of each branch or bureau, and that each chief, in order to accomplish excellence, should have full authority to deal with all matters of detail in which he is a specialist. But all work accomplished by the different bureaus has a common object; what is done in one necessarily affects the business of all the others, and there should be some provision for keeping each chief fully cognizant of what his colleagues are doing in matters affecting his branch, and, at the same time, for assuring intelligent control over the whole organization. This duty devolves upon the Secretary, who, on assuming control, is often confronted with the intricate problems of naval science for the first time in his life, and it is but natural that each Chief of Bureau should endeavor to magnify

the importance of his specialty, and to influence the Secretary in behalf of himself or his particular corps. This state of affairs is not only highly destructive to the maintenance of discipline, efficiency and "strict subordination to civil power," but is apt to lead to the corrupt influences of partisan principles in naval administration.

Professional knowledge and experience then should have due weight in directing measures of administration, and the duty of advising the Secretary in the *general* direction of affairs should be entrusted to one or more officers whose specialty is the science of naval warfare in its broadest sense.

In former days a small "Board of Navy Commissioners" was called upon to administer the affairs of the Department; later on, it became evident that a division of the duties was required, and the Bureau System was inaugurated; now that we have found the Bureau System unequal to the task, it is frequently asserted that the only remedy is a Board of Admiralty, modelled after that of England. Although such a system apparently suffices in England, I am not sure that we could rely on it to serve our own institutions with equal success. English periodicals are often severe in their criticisms on what is regarded as their faulty system, and they often give us an insight into its weakness. It is said that the civil and only permanent portion of that board is "continually at loggerheads" with the executive ranks of the service, and that the efficiency and discipline of the service are disturbed at "the hands of civilian wire-pullers."

What might do very well in England would not necessarily do here, on account of the difference in the political and physical situations of the two countries. The English people is educated to believe that its only insurance on the prosperity of the nation's industries is the navy, and the consequence is that the administration of that navy is carefully and intelligently scrutinized by a people alive to its best interests. The Admiralty is obliged from necessity to avoid the evils of stagnation.

Although the peculiar physical situation of England and the industrial pursuits of her people are safeguards against inactivity in the navy, yet a want of foresight has frequently been apparent in the administration of English naval affairs. The vast seafaring population of that busy nation has gained victories against great odds, but it has often been done with ships and guns inferior to those of their enemies, showing that the administration was not abreast of the times. That system of administration has distinguished itself by allowing

others to lead the way in such innovations as the application of steam and the screw-propeller for war purposes, the development of ordnance in the days of smooth-bores, the adoption of breech-loading guns and multi-groove rifling, and the building of the first-class battle-ships of the present day.

It may seem ridiculous for an American to criticize the system of a power which still holds the "supremacy of the seas," but if it is evident that a system which bears good fruit ought to produce better, and if it is clear that the same system would not work so successfully under the circumstances in which we are placed, there is no reason why we should allow the success of that system to drag us into its errors, and no reason why we should not profit by whatever virtues it may contain.

The great lesson taught by wars which have occurred within the last decade or more, is that one of the chief factors of intelligent preparation for and ultimate success in war is a knowledge of the enemy's condition, resources, strength, tactics, and distribution of force, as well as of our own resources and the best methods for utilizing them for war purposes. Nations have successively profited by this lesson (Germany being the first), and have established in the Navy as well as in the Army, what is vaguely termed a "General Staff," the duties of which are directly connected with an "Intelligence Department";* and the establishment of such a body in our own Central Organization would at once satisfy a pressing need, and enable us to overcome the difficulties previously alluded to.

The following is a summary of the situation:

(1). The authority and responsibility of each Bureau in matters pertaining to its own particular branch leads to efficiency, provided the combined action of all the bureaus can be harmoniously directed.

(2). Professional knowledge in assisting the Secretary to direct the affairs of the Department is essential to protect him from responsibility for mistakes which a want of technical knowledge may subject him to.

(3). The establishment of a "General Staff" for the collection and systematic arrangement of naval information, together with the systematic study of the broad principles of naval warfare as adapted to our own particular necessities, is required, if we are to keep abreast of the age.

* *Vide* Proc. Naval Institute, No. 27, *Naval Intelligence*, by C. C. Rogers, U. S. N.

How, then, can we satisfy these principles in such a way as to sure the success of any reconstruction plan, and at the same time avoid an impracticable and awkward scheme which cannot be put o immediate operation?

The following brief outline of changes in our Central Organization suggested, in the belief that it will meet the necessities of the day the most practicable and efficient way.

OFFICE OF THE SECRETARY AND GENERAL STAFF.

I. *The Secretary of the Navy.*

A *civilian*, cabinet officer, with highest authority under the President or Commander-in-Chief.

His duties.—To enforce civil control and carry out the policy of the Government Administration.

II. *The Assistant Secretary*, or Chief of General Staff.

A *naval officer* of established reputation and broad views, appointed by the President, and holding the rank of Rear-Admiral while in office.

His duties (*a*). To assist the Secretary in the execution of all matters requiring professional advice, for which he will be duly responsible.

(*b*). To act as president of the Advisory Board.

(*c*). To have general charge of the Intelligence Department.

III. *The Advisory Board.*

To be composed, as at present, of officers representing the essential Bureaus, and a civilian representation of private industry.

IV. *The Intelligence Branch.*

To be in charge of a naval officer with rank not above that of Captain, with other officers subordinate to him, engaged in working up the various special branches under his direction.

There is apparently no reason why the Chief Adviser should interfere with any bureau in the execution of its legitimate duties, and harmony would undoubtedly exist if a system of written consultation, similar to that used in conducting the business of the British Admiralty, were adopted as a matter of record. For instance, the Secretary desires to act on a matter requiring an expression of professional opinion; the communication is referred to the Assistant Secretary, who directs

it first to the Bureau most interested, for information or expression of opinion. The Chief of that bureau appends the information over his signature, and then the communication passes through the other bureaus which it affects, for additional annotation and signature; after this it returns to the Acting Secretary, who reviews it and adds his own opinion. The Secretary then exercises his own judgment in the matter, and the communication with its weight of responsibility goes on record.

By such a plan as this, no bureau would be responsible for the faults and errors of the others, but would be clearly responsible for, and would exercise full authority over, all matters belonging to it, and at the same time the Secretary would be provided with a trained assistant, whose function would always be that of mediator between the different bureaus.

I have endeavored to show in the preceding pages the necessity for immediate action on the subject of the reconstruction and increase of the Navy. The question has been agitated in the public press, and Congress seems to be alive to the fact that *something* must be done in that direction; and if that body sees fit to lay down some definite plan of action in the matter, there is apparently no reason why the work should not commence at once. Once begun, the country will again be in the line of progress of nations, and the rising generation will see the United States once more occupying the front rank as a maritime power; and our countrymen abroad, as well as our officers, will no longer have cause to be ashamed of the ships that bear their flag. The country secure against invasion, prosperous in all its branches, will have reached a state of perfect accord with the benediction of our late honored poet, who exclaimed:

"Thou, too, sail on, O Ship of State!
Sail on, O UNION, strong and great!
Humanity with all its fears,
With all the hopes of future years,
Is hanging breathless on thy fate!"

Jan. 1, 1884.

DISCUSSION.

Rear-Admiral JENKINS.—I desire to express in a few words the pleasure I have received at hearing read the Prize Essay by its author (Mr. Chambers). I do not propose to attempt a review, much less a criticism, of the many subjects and heads of subjects it embraces. In so elaborate an essay as the one we have just heard read, there, doubtless, may be divergent opinions, while at the same time, it seems to me, we must accord to it, as a whole, very great merit, both in a literary and professional point of view. That the author has devoted considerable time in thought and research in the preparation of his essay must go without saying, and I think the suggestions made are very fairly and clearly stated and their utility well set forth.

There is one suggestion in the essay which, to my mind, is of paramount importance, if we seriously hope to have a (re-created) navy at all, in the scientific, mechanical and professional sense of the word—a navy as understood at this day throughout the civilized and uncivilized world; and that is an addition to our present *central organization*. In other words, we need an officer whose duties and responsibilities should be the same as those of the "Comptroller of the Navy" in Great Britain. It is not necessary here to state or explain in detail the qualifications and duties of such an officer, as they are well known to all officers.

I am, and rightly ought to be, the very last person to decry or speak the least in disparagement of Boards—as Boards—having myself served for a long time as a member and officer of one, if not the most successful one, in its management of the duties entrusted to it by law. But I am, and have long been, of the opinion that boards should not be called upon to administer anything. They are extremely useful for the purposes for which they are chiefly convened; but for carrying out their own recommendations, after they have been properly accepted and approved, a professional expert of large experience and undoubted ability is in my opinion an indispensable factor to success. Divided individual responsibility, as with cases where boards are required to carry out their own plans, much oftener results in partial, if not in complete failure, than when the whole care and responsibility are placed in the hands of one competent person. Failure with the one responsible officer (if failure there should be) is *his failure alone*. Not so with a mixed board; for then the responsibility is divided, and no father will ever be found to assume its paternity.

It is true that some of the finest vessels of war that any nation ever possessed were built for our government by the "Old Board of Navy Commissioners," composed of three captains of the navy, a secretary, a chief naval constructor and a few clerks; but times have greatly changed since we *had* magnificent line-of-battle ships and frigates, propelled by sails alone. Then, again, I think all who have had much to do with boards have come to the conclusion that it rarely, if ever, happens that there is not one bright, or strong-

minded, or self-willed member who virtually controls his colleagues, while he only bears his proportional share of blame for any shortcomings of the whole board.

In conclusion, I think we owe our thanks to Mr. Chambers for the trouble he has taken to read to us his excellent essay.

Commander Brown.—The arguments of the essayist for building battle-ships of the Italia type are unquestionably good; and if we are to retain our stand on the Monroe doctrine, it is absolutely necessary, in view of the probable completion of the Lesseps Panama, or some other, canal, that we should in the near future possess a sufficient force to maintain command of that waterway. It is true, also, that we must eventually have vessels similar to those of Type I of the Essay, as coast defenders; but, that our cruising navy is not to have vessels of the size of the Chicago or Atlanta—nothing between the displacements of 800 and 10,000 tons—is, I think, a great mistake. The duties of our navy must be chiefly those of protection to our commerce and citizens abroad, of our rights as neutrals, and of the display of a reasonable amount of force (with the assurance that there is more behind it, if necessary) sufficient to make the moral influence of the republic largely felt; and this can be more cheaply accomplished by vessels of the type of the Chicago, Atlanta or Esmeralda, which cannot be obtained even from the enlarged merchant marine that we would all like to see. Experience has shown to our British cousins that their merchant marine, large as it is, cannot be depended upon for this purpose. Vessels cannot be made good freight or passenger steamers and good men-of-war likewise, any more than the best qualities of sailing ship and steamer can be united in one construction.

With regard to torpedoes, the essayist is somewhat contradictory, asserting in one place that "they will render almost certain the destruction of sea-going ships at short range," and in another, that it would be possible for a Thunderer to successfully attempt the passage of a torpedo-lined channel. Torpedoes towing astern would not be of much utility, it appears to me, and the idea that "the transfer of supplies" from the large battle-ships to the smaller ironclads could be accomplished at sea, is one the difficulty of which no one has yet, so far as I know, had the genius to surmount.

It seems to me that enough weight has not been given to the construction of such vessels as Ericsson's Destroyer, which is likely to turn out as valuable an invention as that of the Monitor, and which I greatly regret has not been received with more favor.

Whatever vessels we *do* build, should be constructed in accordance with that system which is thus formulated in the essay:

"No ship should be built that is not superior, or at least fully equal, to those of any other nation of the same type contemporary with it."

With this maxim I most heartily agree, for, following this plan, we should soon be in the relative position we occupied in 1859–60.

The suggestion as to the designs of revenue marine vessels, etc., being under the control of the Navy department is a most excellent one; but I fear that the extreme jealousy manifested by the Treasury officials, at the suggestion

lately made concerning the *personnel* of the Revenue Service, will be again aroused, and that personal interests will conquer those of the general public. The increase of the navy might well extend in this direction, and the 800-ton gunboats would make efficient revenue vessels.

The idea of a general staff is one that is gaining ground gradually; and if we are ever to have a naval policy, it is one that must come to the front. That the Secretary would be much better off with an assistant, as provided in the essay, would seem to be a matter admitting of no debate; but I fear that the millennial period, when such an office could be filled satisfactorily to all schools of thought in the navy, is so far distant that the proposition will not be favorably received.

We all know how ideas which appear at one time Utopian, not infrequently make unforeseen headway; and it is not impossible that the strong navy which the essayist would build up may soon be existent. Some of the debates at the last session of Congress would lead us to suppose that there are a number of our legislators who would gladly see the money appropriated for such a purpose; and it is greatly to be hoped that the possible dangers to which we may be exposed, and which have been so ably recounted by the successful essayist, will arouse a public feeling which shall compel an advance in our defensive and offensive powers.

Lieutenant DANENHOWER.—It seems to me that in case of war with Great Britain a prompt and vigorous stroke against her merchant marine should be made, and that the vessels of Type III would not be adequate to the work. It is stated that the vessels in the freight-carrying trade do not average more than eight knots, and it is proposed to build gunboats of "moderate speed—not less than ten knots at maximum," light draught, and with considerable sail power to increase endurance.

The gunboats to be of about 800 tons displacement and to cost $300,000 each. Type III is very similar to the "light gunboat" proposed by the Naval Advisory Board, to have about 750 tons displacement—nine feet draft—to be suitable for seagoing work as well as that on the Great Lakes, and to cost, when fully equipped and armed, $269,000.

In the event of war Great Britain could immediately patrol the principal routes of trade with cruisers far superior to those described above, and her fleet would soon be reinforced by her trans-Atlantic steamers converted into swift cruisers, with speed, armament and torpedo accessories far superior to those of Type III, and the latter would not be found in accord with the sound maxim of the essayist: "No ship should be built that does not designedly occupy her place in the great scheme for national defence."

To perform the work proposed for Type III, viz.:

(*C*) "To intercept the enemy's food and industrial supplies in transit to the seat of government," it seems to me that a special class of gunboat of about 1000 tons displacement, not less than sixteen knots speed at maximum (eighteen would be preferable), and to be armed with one six-inch B. L. R. and two machine guns would be necessary. The gunboats to be constructed of steel and to cost about $350,000 when completely armed and equipped. To be

lightly rigged with most improved spars and sails, and to have as small a complement as possible consistent with service intended.

This class of vessel should be sent to the Asiatic Station and to the Pacific coast, but the greatest number should be kept on the Atlantic seaboard, in squadrons, which should move and exercise together and be in readiness for prompt service. Should trouble occur in the West Indies or on the Isthmus, a squadron of gunboats could go quickly to the scene of disturbance, to be followed, if deemed necessary, by the "battle-ships" of Type II.

On the eve of war this class of gunboats should be ready to prey upon the enemy's commerce, and with such a standing menace to its merchant marine, Great Britain would not suddenly spring a declaration of war upon us as she might now in our present condition. Such a gunboat could cruise under sail and steam on the highways of trade, capture and destroy the freight-vessels and elude the superior vessels of the enemy, but giving battle to equals and fighting bows on with her 6-inch rifle. The maximum speed would seldom be needed, and the easy speed of eight to ten knots could be maintained and the gunboat have more than the average endurance at sea, for her armament and complement being very small, her coal capacity would be greatly in excess of that of the average vessel of her tonnage, and could be made a protection for her. The estimated cost of the Chicago is $1,295,000 when fully armed and equipped. Four of the swift cruisers above described could be built for one Chicago, and for the special service intended they would be superior to her. These little Cossacks of the sea could also harass the English coast and keep a good portion of the British fleet diverted from our own coast.

In discussing the subject of the reconstruction of the Navy and the means for defending our harbors and coast, a full investigation should be made into the merits of a system of defence by permanent floating-batteries and by heavily armored turrets on outlying islands and points of land. A large circular hull, supporting a heavily armored citadel containing high-powered rifle guns, would make a strong defence when supported by submarine mines, powerful rams and numerous torpedo-boats.

The first cost of such batteries would be much less than that of the vessels of Type I ($2,000,000), and their maintenance would be a small fraction of the sum usually expended on a heavy ironclad. Such a battery would afford a steady platform, and would present a small target. It could be towed into position and only a limited amount of machinery would be needed, viz. for working guns, electric lights and torpedoes, also for ventilation. The citadel could be made practically invulnerable, and the gunnery from it could be far superior to that from an unsteady platform, such as a moving vessel. The battery could be moored in a deep place between shoals which would afford a protection against rams, and the defence against torpedoes could be effected by permanent iron nets on out-riggers and by having many compartments in the hull. If assailed by boarders they could be repelled by streams of scalding water, grenades and machine guns. The floating-battery could also be made an aid to navigation. They would, doubtless, last much longer than the proposed armored vessels of Type I (Class A), and would be comparatively inex-

pensive. The turrets spoken of are to be used at commanding points, and to be supported by earthworks from which a body of soldiers or the naval brigade could resist an assault. The turrets to be heavily armored and to mount heavy rifles. They would make small targets for the enemy's shot, could be put where heavy fortifications could not be built, would take less time for construction and would be less expensive.

By this system a permanent water-line of defence could be established about ten miles from Boston Common and arranged to protect Marblehead and Salem. A very effective inner line of turrets on small islands and floating batteries, to enfilade the mid channel, could be made in Boston harbor.

Floating batteries could be moored inside of Sandy Hook, between the shoals, to command Gedney's and the east channel, while heavy turret batteries on Sandy Hook could sweep the south channel.

Three floating batteries moored inside of Cape Henlopen in six fathoms water could concentrate on the main channel, and turrets on Cape May could command the narrow Cape May channel of the Delaware.

The Chesapeake could be defended in this way, and the system of defence could be used at many places on the Great Lakes.

A strong line of defence from Fisher's Island over to Plum Island could keep the enemy out of the middle part of Long Island Sound, and prevent the ravage of the Connecticut cities near the shore.

It would be better to keep the floating batteries moored in their places and always in an efficient condition, though it might be deemed advisable to lay them up until the first indication of war.

Twenty such floating batteries could doubtless be constructed for less than it would cost to fully arm and equip ten of Type I, and would be more effective in defending the coast. There is one point more about the proposed Type I, (class *a*). I do not think that with maximum speed of eight knots and steaming capacity of only 3000 miles they would be considered available to send down to the American Isthmus, when we get into trouble with France over the canal subject. The "battle-ships" of Type II will then be required, and the "Rams," (class *b*), Type I, with many torpedo-boats, which latter are not held of special importance in the essay.

It is true that we are in a totally helpless condition, and the sooner we can make the country appreciate the growing power of the mighty empire on our northern border, as well as the complications with France that we are so liable to experience, the sooner will the absolute necessity for a navy be realized and the appropriations be forthcoming.

Commander Hoff.—We have just heard read the most interesting essay by Mr. Chambers, which I am certain we have all enjoyed, although there may be some things in it with which we do not agree. Certainly some of his ideas which bear upon naval tactics are sufficiently novel to be discussed, and I now take advantage of the opportunity afforded me to make the following remarks:

If Mr. Chambers built rams at all they would be rams "pure and simple." This form of vessel, once so popular, has passed out of the minds now of

tacticians as a war factor. Rams are necessary and will be built, but they will be furnished with torpedoes and mechanical guns, although the ram is to be considered their principal weapon. They have two screws, it is true, in order to give them the proper tactical mobility, but it would hardly do to pin your faith on engine power alone. Besides this, according to Captain Chabaud-Arnault, the ram is the *only* vessel which can use an auto-mobile torpedo in a naval duel, from a broadside installation, since it alone can fire across its tactical diameter, and, therefore, that weapon should be supplied to this class of vessel. The range of this weapon is set down, after years of experience, at 200 metres at sea. It is easily seen that such a weapon used from such an installation, which could not reach the opponent of a vessel engaged in an artillery duel, and circling, would be very dangerous, especially as it is now thought that the limit of torpedo range has been reached; not from the fact that the limit of invention in this direction has been attained, but from the inherent badness of the element in which this arm performs its trajectory.

Mr. Chambers also speaks of fighting his enemy stern to, in his "dangerous wake," as he calls it, where the enemy must stay as long as Mr. Chambers chooses to keep him there. The essayist also speaks of "stern rams" and torpedoes towed in his wake to prevent ramming.

Tacticians say, history proves that in action only 25 per cent. of shot strike effectively at 450 metres. Now, if there is to be a *combat*, the ships under consideration must first come sufficiently near to make their shots tell, and then we will suppose Mr. Chambers to round to. Let us put this distance as great as 1000 metres. Although Mr. C. will have his ship's stern towards me, still I am not in his wake, and his torpedoes will do me no harm. I am not in his wake until I, chasing him, come to some spot which he has left. This I, as a skilful commander, will never do, but I will keep out of his wake altogether by running alongside of it; and will only *cross* it when he compels me to do so by turning. I would not fear his torpedoes at this time, since it would require too neat a calculation for him to make to throw me on top of one. Should I be obliged to stand on in his wake I would not worry about being blown up, as the results in the French navy show that torpedoes do not explode against a target which makes an angle of less than 30° with the line of sight, and my stem is at a much less angle than that. Then, again, the disadvantage will naturally belong to that vessel whose screw and rudder are exposed, although perhaps a "stern ram," whatever that may be, might put us on a better footing in this respect. Again, suppose I am chasing Mr. Chambers, and he wishes to give me the benefit of the fire of anything but his stern battery; every time he turns or twists, I having to turn on the circumference of a larger circle to keep my head on him, have my speed less injured, and so every time he touches his helm I gain on him, until finally I ram him.

Now, if he stands for me in the first place to a distance of about 600 metres, and then rounds to, I would ram him before he could turn through sixteen points, since I could cover the distance between him and myself quicker than he could turn through the required number of points. Lieutenant G. N. Bethell, R. N., for this reason says, no commanding officer can wittingly permit

a vessel to enter his wake at a less distance than 700 yards, and Lieutenant Besson, of the French navy, lays it down as a theoretical principle, which experience has proved true, that in a duel, if one vessel wishes to engage in a ramming contest, the other vessel will be obliged to do the same.

Another point about fighting in chase. If I am fighting Mr. Chambers and disable him, he drops into my jaws. If his fire, on the contrary, damages me, I drop out of the fight and probably make good my retreat.

As regards Mr. Chambers making use of his smoke to blind his pursuer, I am of the opinion that the most thoughtful tacticians look upon smoke merely as an unmitigated nuisance, as bad for one party as the other. It is a screen between you and your enemy. You each fire at a target you cannot see.

What I have said about single ships also applies to the essayist's remarks on fighting fleets with his stern towards them, but with still greater force. In the nature of things, the fastest of the pursuing squadron would gain on the slowest of the chased squadron, the mutual support of the vessels in this latter would be broken up, and the formation becomes flanked. If you attempt to succor your lagging vessels, now beset by the enemy, you would have to turn, and if you turned you would probably be rammed before you got your head in the required direction. So, in conclusion, I merely venture the remark that Mr. Chambers' wake is more "dangerous" to the pursued than to the pursuer.

Lieutenant-Commander Elmer.—I had not intended to take part in the discussion this evening. With what appears to me the main point of the essay, the absolute necessity of armored vessels, both for offence and defence, I agree heartily, but there is one point in Commander Brown's criticism with which I desire to express my concurrence, and that is the mistake in confining our cruising or unarmored navy to gunboats. The essayist would seem to have devoted his attention too exclusively to a war with Great Britain and the consequent importance of transferring a naval force from the Gulf to the Great Lakes; on no other ground can I see any argument for thus frittering away strength. Aside from the loss of *morale* to the service at large, inseparable from almost continuous gunboat service, and to my mind that is an important point, these vessels would make but little show of force, and exercise but little of that moral effect so necessary in our intercourse with semi-civilized powers. The great draft of water of the "battle-ships," Type II, would shut them out of most ports and render them of little value as peace cruisers; in all such places we would be dependent upon gunboats to protect our interests. During the past twenty years it has been frequently necessary, especially on the Asiatic and Pacific stations, to send on shore landing parties to protect property or punish offenders. It would require a fleet of lightly manned gunboats to furnish as effective a landing party as one Chicago.

The moral effect of the possession of a few heavily armed, fast cruisers was shown in the late French and German war, when the entire German mercantile fleet was laid up at the outbreak of hostilities.

While appreciating the value of the floating batteries or turrets described by Lieutenant Danenhower, as portions of our coast defence, I cannot see how they will take the place or do away with the necessity of vessels of Type I,

whose duties will be offensive as well as defensive, raising or preventing blockade as well as defending harbors.

Commander GOODRICH.—The essay is marked by an earnest desire to reach a logical solution, based on strategical considerations, of the problem proposed. It will, doubtless, be criticized after the fashion which is but too common among us and be pronounced as admirable, or the reverse, according to the passing fancy of the critic. For myself, I think it an able and suggestive paper, although I am unprepared to accept the plan in all its details as the best to be followed in our naval *renaissance*. The writer has given the subject careful thought. Those who oppose his deductions should remember this fact, and its consequent obligation not to find fault lightly, and they should seek to destroy only where they are ready to build up.

I have noticed several points to which attention might be profitably directed, but as most of these have been touched upon by others, I confine myself, at the risk of repetition, to a few which seem of especial importance.

I am glad that the writer insists upon sufficient depth for his battle-ships, and am strongly disposed to claim the same element for all large vessels. The most successful naval architects are not hampered in this constructional dimension, upon which simplicity of engine design and economy of performance, combined with high speed, are so largely dependent. I venture to hope that the day will soon come when it will be generally conceded that big ships need deep channels, and that the former should be built without the ruinous condition of ability to enter every port on our coast.

In his schedule of ships I am naturally disposed to complain of the sins of omission. Throwing out his "torpedo-proof auxiliary supply vessels," I agree with him fully as to the necessity of his three types, but in my opinion it is neither desirable nor expedient to deprive ourselves of such fighting powers as are possessed by the Riachuelo, for example, which displaces less than half as much as his proposed battle-ships and which costs vastly less. With the exception of the Italian ironclads, the Dandolo, Duilio, Lepanto and Italia, the French Baudin, Amiral Duperré, twenty others, and the English Inflexible, Benbow and twenty others, the Riachuelo could render a good account of herself in action with any vessel afloat to-day. It would appear a wise economy to introduce a number of such powerful and relatively inexpensive ships into our new navy. Granted that a $3,500,000 Italia* could engage, with practical certainty of victory, any ironclad extant, why should we be forced to use so tremendous a weapon to crush an antagonist not half as strong? Better to adapt the tool to the work, have a number of second-class ships, the *best of their kind*, and call upon the battle-ship when the enemy brings out his greatest strength. It must not be forgotten that *numbers* are of as much moment oftentimes as individual strength, even in naval combats.

The Chicago and Boston types should be preserved, at least so I think, as a reply to future vessels similar to the Esmeralda. Much of our current duty abroad takes the shape of armed landing parties. The deep draft and unwieldy

* The Italia has already cost half as much again.

battle-ship is often ill adapted to such work, and the crews of the proposed gunboats would be ridiculously inadequate. For this purpose the crews of the Chicago and Boston might well be made as numerous as the berthing space on board will permit. If to these two objects we add driving away from an outer blockade any unarmored ship of the enemy, acting as armed despatch boats, breaking up a convoy, destroying lines of communication—in short, doing a hundred things which an ironclad should not be employed to do, and which a gunboat could not do, I think we shall find abundant grounds for self-congratulation upon the possession of a class of ships which, as far as they go, are really so admirable that they are being widely copied abroad in all essentials.

The question suggested by the essayist as to the probable outcome of an encounter between a Chicago and a torpedo cruiser is easily answered. The latter would be seriously crippled long before getting to close enough quarters to be effective. In discussing the value of machine guns the fact is too often lost sight of that their aim is corrected by the fall of the shot. Beyond the distance at which this phenomenon can be noted, machine guns may be or may not be useful—it is largely a matter of luck.

The essayist is not the only person who trusts to the merchant marine for improvised Atlantas. Beyond the probability that we could ill afford to spare any fraction of our very meagre troop-transporting power, there remains the fact that a makeshift is a makeshift after all. To fit them for carrying efficient guns of the present standard would involve their practical reconstruction and introduce serious complications into the matter of stability.

If swift enough to escape an armed foe they would damage unprotected commerce very seriously, but, at best, they could never properly replace during war such well-contrived fighting craft as our new cruisers, while the latter will serve as excellent schools at all times, and be as effective as the heaviest armored vessels in distant operations on barbarous coasts, and but little less so in encounters with other unarmored ships. For these reasons I am inclined to doubt the possibility of England's equipping from her mail steamers a fleet of cruisers more powerfully armed than the Chicago, as stated in the essay.

The essayist considers the moot question of how best to arm our fleet, and arrives at conclusions opposed to those of the Gun Foundry Board. As the members of this Board enjoyed unequalled opportunities of investigation, one is forced to accept their recommendations as final, and to protest in the most positive terms against the proposition of a government loan in any form to private establishments. The steelmakers should be encouraged to put up adequate plant for the production of their metal in suitable masses, by contracts for current supplies sufficiently large in amount and extending over sufficiently long periods to make the undertaking profitable.

Similarly, the construction of a certain number of guns annually should be entrusted to two or three responsible firms, to enable them to supplement the government shops in time of need.

I am sorry to see the essayist wander away into the field of political economy and lend the weight of his pen to the doubtful project of reestablishing our

lost commercial prestige by resorting to subsidies. How this plan worked in the cases of the Brazilian and the Pacific Mail lines should not be forgotten.

A prize essay published by so important a body as the Naval Institute goes before the world stamped with a rare authority. While the author is, of course, alone responsible for his views and statements, still, to prevent misapprehension, I think it well to urge that subsidies are *not* generally approved in the naval service or out of it, and that the more rational method, by the removal of harmful and vexatious restrictions, has many and strong advocates.

The writer has formulated a scheme of supplementary naval administration, whose adoption, more or less on the lines proposed, seems inevitable if the navy is to become a fighting machine. At present, with a dozen or more persons legally competent to issue an order to a commander-in-chief, and a separation of the navy into a number of bureaus, whose efforts are not always free from the suspicion of self-interest at the expense of the service at large, the wonder remains that even a lesser measure of efficient co-operation should not exist.

Without entering into details I think the proposition to use the battle-ships as transports for ammunition, coal, men, guns, etc., ought not to pass unchallenged. The ideal navy would contain no fighting vessels weaker than the Italia, I grant, but, as it is quite out of the question to have such a navy, a wise economy would seem to suggest the replacing of a few Italias by two or three times their number of powerful second-class ironclads.

I have not touched upon all the points covered by this interesting paper. Many of those passed over in silence deserve our heartiest commendation. One I venture to quote nearly in the author's words: *No ship should be built that is not superior to those of any other nation, of the same type, contemporary with it.* The observance of this principle prior to the rebellion secured for us the respect of the civilized world; its neglect since then has made us the world's laughing-stock.

In general terms the essayist's scheme of reconstruction appears excellent. Individually, and for the reasons indicated, I think it should be extended to include a fair proportion of Riachuelos, Chicagos and Atlantas. I should like to see these modifications introduced, but better a thousand times execute the scheme as it stands, than not adopt some well-matured and progressive system similar on a small scale to that which, settled upon by France in 1871, enables her to-day to dispute with England the claim to naval supremacy.

Lieutenant T. B. M. MASON.—Our Prize Essayist has so clearly and completely stated his case that little remains to be said from his point of view. Although we may not all agree with him in every particular, still I think that we must admit that, as a general scheme for reconstruction, or rather construction, of our navy, his plan is very nearly what we require.

Those who have criticized the essay have strengthened it, as a whole, by finding fault with so few of its details.

There are a few points upon which I would thank you to hear me.

A "peace navy" every thinking man knows to be a farce. A navy must

be created gradually, and cannot be improvised, except to oppose an enemy laboring under similar disadvantages.

There is no more sense in a "peace navy" than there could be in a city's fire brigade organized and equipped for other than its legitimate duties. Like a fire brigade, the naval force of a country, be it large or small, must always be prepared for action. It must be thoroughly equipped, manned and disciplined, so that at any moment and from any cruising distribution it may enter upon active operations against an enemy.

If besides its regular duty of preparing for war, a modern navy can be made useful in the advancement of the maritime and scientific interests of a country, so much the better for the treasury; but it is doubtful whether the disadvantages of withdrawal from professional preparation and the antagonism of civilians shut out of employment will benefit the navy in the end. One thing is certain, and that is, that civil duties should never be allowed to interfere with naval ones. Our people must be made to understand that a navy is for war. Once that fact is well understood there will be no necessity of making excuses for its existence in time of peace. They should also be brought to appreciate the fact that the navy does not belong to the administration, the department or naval officers, but to the people, who, through their representatives in Congress, are entirely responsible for its condition. Therefore, that when our illustrated papers, and the press generally, ridicule the navy they are ridiculing their own belongings and accentuating their own neglect of the national interests. When a fire engine breaks down it is quickly repaired or replaced. When a fireman is seen reposing himself awaiting a call to duty he is not held up to ridicule and animadversion as a useless member of the community and an unnecessary expense.

Our regular navy will probably be called upon in the event of war to perform the active work on the high seas and to furnish leaders and a disciplined nucleus for our coast defence. We have no reserve to draw from for deep-sea work; our small number of deep-sea merchant service officers and men will be required to officer and man the ships upon which they are now serving when converted into transports, supply and hospital ships.

The crews of the coast defence ships must be led by trained officers and a few trained men; these in time of peace will be required to guard and keep in order their ships, and to train the people required to complete their complements in time of war.

The armor-clads, gun-vessels and torpedo-boats of the coast defence should be built to meet the necessities of the part of the coast which they are expected to defend. If possible, they should be built near their scenes of operation, so that local pride might be aroused in regard to them and local interests developed. In time of peace they should be stationed at the principal ports of their base in order that their war crews might be accustomed to their duties. These war crews should form a corps of national naval militia, or, if considered best, State corps of naval militia, enlisted in the same manner as the present land militia, but uniformed, organized and disciplined as seamen. We have seen during the last summer a regiment of militia doing garrison duty in a sea-coast

fort as artillery. Summer camps are occupied every summer. Why should we not have summer cruises and winter ship drill?

The vessels of the Revenue Marine and Coast Survey should be built under supervision of the Navy Department even if these services remain under a civil head, and their officers and crews should be prepared to fight their ships in defence of the coast. The tenders of the Light-House service should, in like manner, be prepared for use in placing and working torpedo mines, a duty for which their appliances and expertness in handling buoys seem to fit them.

It is very doubtful if any reliance can be placed upon our merchant marine to furnish cruisers. The best of English authorities seem unanimous in declaring that in their case it would be an impossibility, and every one knows that they have the best plant for such an undertaking. The experience of our last war teaches us that the price paid by the government for merchant steamers was far in excess of that which would have provided and kept in preparation regular war vessels.

Our people must not be carried away with the torpedo-boat craze, and it is the duty of naval officers to explain to them that torpedo-boats are a part of the system of coast defence, but not the whole of it by any manner of means. The results of foreign experiments show that a properly equipped modern vessel has not much to fear from torpedo-boats under ordinary circumstances. The coast defence must consist of a judicious mingling of guns, ships, rams, forts, torpedo-boats and fixed and auto-mobile torpedoes. There are no two harbors which can be defended in exactly the same way. A thorough and impartial study, made in the locality itself by a mixed board of naval and military experts, should decide what is necessary for the defence, what portion should be undertaken by the navy, and what by the army.

An officer of broad naval experience, as a commander in war and peace, as a Chief of Bureau and member of the Light House Board, has given his opinion in regard to the fallacy of board rule. There is another class of rule which is even worse, and that is the rule of nine executive heads, serving independently and claiming equal authority in the management of naval affairs. We never can have any sort of a modern war navy until the construction of our material is centralized, or until our active navy is placed entirely, both as regards personnel and material, under one naval executive. The appropriations made by Congress might be made to support a small modern war navy if judiciously apportioned, but it falls utterly short of its purpose when we try to run nine separate organizations. It is not overstating the case to say that the present organization, or rather want of organization, of our central control is the greatest obstacle which the navy has to contend with in any effort of reconstruction; and since Congress has erected this obstacle, Congress alone can remove it.

There are a few more points for which I must ask your consideration. We have no docks capable of docking the largest type of vessels proposed. Ships without docks would soon become useless. Docks require as much time to build, if not more than, ships; therefore, when we commence our ships we

must commence docks for them, located where they can best reach them in time of war.

In order that tools may be handled to the best advantage the workmen must have experience in their use. This seems to be one of the strongest arguments for a war navy. If the country is to get the greatest advantage from its costly ironclads, cruisers, gun vessels, rams, and torpedo-boats in time of war, they must be commanded and manned by the officers and men who have handled them in time of peace. Granted that on the outbreak of war the government should discover a spare Aladdin's lamp and wish a war navy into existence, it would take months to prepare the personnel.

The Chairman, Commander FARQUHAR.—This discussion has been very instructive and interesting. The various points for and against the essay have been well put. Indeed, so well has it been reviewed that there is little left for me to say.

It seems to me that to build a man-of-war to have a less speed than seventeen to eighteen knots per hour is a waste of money, unless the vessel should be intended for harbor defence or only for cruising in times of peace. In this point of speed I think all of the vessels proposed are defective, and Class III almost useless.

It is to be hoped that as one result of this essay Congress will be induced to appropriate money to rebuild the navy.

I fear very much that the sinking fund obtained from the sale of old vessels will not be a drop in the bucket as to what will be required to keep up an effective navy.

Ensign CHAMBERS (the Essayist).—I am flattered by the amount of criticism which my essay has evoked, and am glad to have an opportunity to reply, and to elucidate parts in which my meaning seems to be somewhat obscure.

Commander Brown asserts that certain statements are contradictory, but a more careful perusal of the essay will show that such is not the case. The statement that torpedoes will render the destruction of sea-going ships almost certain *at short ranges* does not apply to operations in a torpedo-lined channel, and I can scarcely regard the Thunderer as a sea-going ship, particularly when encumbered by a cordon of auxiliary vessels, possible in a harbor only, for protection against torpedoes. This use of auxiliary supply vessels, by the way, was mentioned merely to show the possibilities of torpedo protection in coast defence vessels of existing types.

Ericsson's Destroyer I relegate to the class of torpedo boats provided for in the essay, but I cannot regard that vessel, with her want of speed, and the want of range and accuracy of her torpedo projectile, as a first-class vessel of the torpedo-boat type.

In regard to the transfer of supplies at sea, a difficulty which Commander Brown thinks no one has had "the genius to surmount," several methods have been suggested which, like many other important tactical problems, still slumber in the realms of conjecture, oblivious of the certainty and economy attending a few trials or experiments. I consider myself fortunate in having had an oppor-

tunity, while on board the coaling steamer Loch Garry, with the Greely Relief Expedition, to settle the problem to my own satisfaction. While towing the Alert from Godhaven to St. Johns, and on getting into rough weather, the steel towing hawsers parted several times, and it became necessary on one occasion to send her the end of a hemp hawser, and on two other occasions to obtain from her the end of our broken steel hawser, the ships meanwhile towing by the remaining hawser. Cork fenders were used in sending the hauling lines, and our steam winches made light work of hauling both fenders and hawsers on board. I was convinced at the time that, with the proper towing arrangements and without other facilities than those which could have been improvised on board, I could have transferred, without much difficulty, our whole cargo of coal, which was stowed in bags of 100 lbs. each.

It is generally conceded that a certain number of Chicagos or Esmeraldas could protect or destroy commerce more efficiently than could the same number of gunboats, and I am sure we would all prefer, for the sake of comfort, to serve on board ships of the former class; but it is only by regarding our peace-footing as a *unit*, and the work it would have to do both in peace and war, that we can see the policy of doing without the intermediate class of vessels during peace, and of relying upon our merchant marine for them in time of war. So far as I know, it is generally conceded that we need battle-ships, and I hold that they should form a part of our regular cruising fleet in times of peace, in order to properly maintain our prestige abroad, to accustom our personnel to their use to prevent their being an expensive dead-weight on our hands during peace, to regard them as a standing menace to foreign nations against a hasty resort to arms, and, particularly, to ensure their efficiency when required for war service. In England the advocates of a commerce-protecting fleet are numerous, but I do not think the magnitude of the work imposed upon such a fleet is seriously recognized. I do not believe the combined fleets of Europe could afford absolute protection to goods carried in merchant ships under belligerent flags, without maintaining an effective blockade. It is supposed that commerce could be protected either by convoy or by commerce-protectors stationed at the crossings of the trade routes and patrolling the lines between them; but the former would require a convoying ship to each merchantman, and both methods would furnish easy prey to a few battle-ships, or cruising flagships, passing from one trade crossing to another, *en route* to the United States. It would be very obliging in our enemy thus to station his ships, at certain well-known localities, where a few powerful ironclads could destroy them, as well as a great portion of the commerce, in detail and in very short order. There would be great doubt about the protection, even if our enemy could send a fleet of battle-ships to each of the numerous trade crossings. To obtain the protection of neutral flags, as did the Peruvian merchants during the Chilian war, nothing more is required than the completion of certain arrangements involving the payment of money and the signing of names; and, therefore, if the only safety for commerce during war lies in a transfer of flags, a special fleet of unarmored commerce-destroyers does not possess sufficient importance to make its maintenance during peace a great necessity.

A transfer of flags would probably raise the premiums on insurance and freights, and trade would suffer to a limited extent, but it would not force a capitulation. England is the only power whose commerce is vital to her existence, but no nation can protect its commerce nowadays from the ravages of a maritime power, and I am persuaded that, with the Alabama's deeds fresh in memory, and the existing facilities for communication with all parts of the world by telegraph, shipowners will not again delay action as long as did ours during the Civil War.

It must be borne in mind that Congress is always backward in appropriating funds for the Navy, and our construction policy, to be successful, should be based on the *combined* efficiency of our *nucleus* for war purposes. And if, as I suppose, the protection or destruction of commerce during war would be of minor importance, the most efficient nucleus possible would be that created by devoting the greater share of our appropriations to coast-defenders and battle-ships, the latter of which are commerce-destroyers, as well as destroyers of commerce-protectors, *par excellence*.

Another point: the more attention we give to special commerce-destroyers before war, the sooner a transfer to neutral flags will take place; and if we can relegate the destruction of commerce to our improvised merchant steamers, the greater will be the confidence of our enemy's merchants, the slower the transfer, and the greater our opportunity to injure the enemy. Furthermore, if we reconstruct our merchant marine with a view to efficiency for war purposes, our shipowners will take precautions to deliver their ships quickly for sale to the government at the opening of hostilities, instead of transferring them to neutral flags.

Generally speaking, fighting ships, regardless of efficiency, can be improvised quicker than they can be built. Commerce-destroyers can be improvised quicker than battle-ships, and, in the event of a modern war, blow will follow blow in such quick succession that we should be ready to do a certain amount of improvising in order to gain as soon as possible that power which sometimes obtains more from numbers than from individual efficiency. And for the very reason stated by Commander Goodrich, "a makeshift is a makeshift," it would be sound policy to assign our makeshifts to the least important class of our war footing. Rather be obliged to improvise a hundred Chicagos or five hundred Dolphins than one battle-ship. Moreover, if a reliance is placed on those makeshifts they will be more efficient as fighting ships, when the transformation takes place, through the care that will be taken to make them so.

The latest merchant steamer added to the Admiralty Contingency List, the Umbria, can steam around the world, without stopping, at the rate of 15 knots per hour, her cargo space being used for coal and her stability being maintained by substituting water ballast in compartments for the coal consumed; she can also steam for 16 days at the rate of 18 knots; she possesses unusual structural strength, great beam in proportion to length, and, although her displacement is over 10,000 tons, her deep draught is but 22.7 feet. As efficiency is directly proportional to endurance, speed and power, I think a study of this vessel will substantiate my statement about the Chicago, to which Commander Goodrich takes exception.

As to the adaptability of improvised vessels for carrying guns, I would refer to the Hecla, English improvised torpedo supply ship, which, in addition to her supply of torpedoes and torpedo-boats, is said to carry her six battery guns very well. The Angamos, a Chilian cruiser, hastily improvised from a beef-carrying steamer, is another example of the possibilities in this direction. She was armed with one of Armstrong's late-pattern high-power 8-in. B. R. L.—the want of guns only prevented her carrying more—and she distinguished herself in the bombardments of Arica and Callao by her remarkable firing at 8000 yards. But for the unfortunate accident at Callao, caused only by faults in the gun, she would doubtless have rendered a still better account of herself.

Whatever be the merits of an improvised cruiser, as compared with those of a Chicago, I think the cream of a merchant fleet, improvised and equipped for war purposes only, could be relied upon to destroy merchantmen hampered by commerce, and to avoid the enemy's ironclads, quite as well as the same number of Chicagos.

But my principal reasons for recommending this reliance upon the merchant marine are: (1) to ensure its reconstruction along with that of the navy; (2) to create a better knowledge of naval requirements in marine architecture among our private builders, and (3) to produce such a merchant marine as will be most efficient and more economical than it heretofore has been when called upon to increase our power during war.

The false economy, however, resulting from a too implicit reliance on the merchant marine should be carefully guarded against, and we should never entertain the idea that it could be relied upon for our most important types. If I were to accept the present general type of merchant steamer as the nearest approach to a fighting ship that could be produced with economy to its more legitimate uses, I might hesitate about placing so much reliance upon it. But if we will only furnish the proper encouragement to those who are already at work on the problem, great strides of improvement will result in the future. Several plans and petitions are before Congress, and if the claims of some are substantiated the problem is solved already.

If we fail to encourage the reconstruction of our merchant marine, and thus neglect to foster our shipbuilding establishments, we might as well admit our inability to build our own ships for national defence, and allow our possible enemies to excel us in the skill which is vital to the protection of our industries.

I think that naval officers are unanimous in condemnation of the vexatious and harmful restrictions imposed upon our merchant marine by our navigation laws. Their views concerning subsidies have been quite freely recorded in a previous prize essay devoted especially to the merchant marine; but whatever be the weight of opinion, I wish to urge my plea (1) for the encouragement necessary to allow our shipbuilders to increase their facilities and thereby reduce the cost of production without a corresponding reduction in the wages of skilled labor; (2) for the encouragement necessary to allow shipowners to possess ships of the best quality only.

If England and other countries find it necessary to grant liberal subsidies

for the performance of public service, such as carrying the mails, we can improve on that policy, only by making the percentage of subsidy depend upon individual efficiency for war purposes.

Subsidies are not usually advocated in the interest of shipbuilders or from disinterested motives, and in advocating them I wish to emphasize the necessity for protecting them from vultures by surrounding them with such conditions as will ensure increased efficiency in ships and increased study and competition among builders.

This is an age distinguished for the moulding of Utopian ideas into practical truths, rendered so by mechanical skill and genius; and even at the risk of a strong opposition, I wish to advocate a measure calculated to raise the premium on skill and to encourage genius.

I endeavored in the essay to point out the value of gunboats cruising on foreign stations, in combined operation with the flagship; for by means of the gunboats, the ocean-monarch, the battle-ship, provided with a numerous crew, is enabled to transport her power into shallow waters or to spread that power in different directions at once. I know of no combination more powerful and economical, or better suited for landing parties and for the display of our flag in semi-civilized or barbarous countries, and it is pre-eminently adapted for a school of tactics, experiment and experience.

The battle-ships would represent the power to ensure our prestige abroad, and would not draw as much water as the majority of flagships. The English rely upon two ironclads to perform, alternately, the duties of flagship on the China station, simply because all other available ones are too deep to pass through the Suez canal, 24.5 feet being the limit. Service on board both battle-ship and gunboat would represent the extremes of experience, which would fit officers and men for the intermediate types also. The internal economy of the extreme types could be readily adjusted to suit that of the intermediate ones, and the combined action recommended in the essay would produce a high standard of efficiency.

I like Lieutenant Danenhower's picture of the "little Cossacks of the sea," and I accept his 1000 ton vessel for Type III. One of the dominating ideas in writing this essay was to disparage an old method of laying down types, an offspring of sailing ships which has survived their decay, and to insist that the absolute tonnage is the last thing to be fixed. When the 1000 ton vessel is completed, perhaps some other critic, following the same reasoning, will exclaim, "But our enemies can patrol the lines with vessels superior to the above, let us build them of 1200 tons!" after which others will continue the strain with 1500, 2000, 3000 or 5000 tons, and so *ad infinitum*.

Then again some one will demand an increase of speed by eight or ten knots, and I will distinguish myself by demanding thirty knots and no less.

If we can obtain a 1000 ton cruiser having "more than the average endurance" at the "*easy* speed of eight to ten knots" under steam, I think we have already arrived at the goal of perfection in naval architecture.

Lieutenant Danenhower is mistaken in stating that Type III is not in accord with the maxim, "no ship should be built which does not designedly occupy her place in the great scheme for national defence."

It was the necessity for a class of vessels to operate on the great lakes and in our shallow coast-waters and rivers and to harass the enemy's commerce with the first notes of war, which preceded the conclusion that the same type would be suitable to perform the greater part of the work with which our cruisers are constantly occupied during peace. The first restriction to place upon them was light draught; with a load or sea-draught somewhat greater, inasmuch as they could be deprived of the greater part of their endurance, their sail power, on arriving in the United States. They were required to be handy, which imposed a certain restriction as to size, and to be habitable and seaworthy; and with the performances of recent vessels of the same type as a general guide, I considered 800 tons and a sea-speed of ten knots a safe margin. But I also laid down the maxim, that no ship should be built inferior to any other of the same type contemporary with it; and if the conditions can be satisfied, and a speed of twenty knots with sufficient endurance can be obtained in a vessel of 1000 tons, I think that is the kind of a gunboat called for by the essay. Although a little skeptical about the possibility of driving such a gunboat in moderate weather at sea more than ten to twelve knots, I am confident one could be built to attain eighteen knots in smooth water.

My ideal gunboat would be fitted with Hereshoff or Belleville boilers and high revolution engines, with small twin-screws attached to shafts having universal joints under the run, so that they could be lifted up at each side when under sail. Steam could be raised and the screws lowered in a few moments, when required, and the utmost economy could be practiced with regard to the use of sails. Their protective decks could be arranged so as to be readily fitted with extra armor and greater offensive power after their spars had been abandoned, on arriving in the United States; after which they would represent a coast defence type similar to that proposed by Admiral Porter, valuable on the lakes and in chasing blockading cruisers from the coast.

I agree with Lieutenant Danenhower that a full investigation should be made into the merits of a system of defence by permanent batteries, but as no nautical skill in the handling and care of such batteries would be required, I regard that as an army problem. I do not think, however, that the army would conclude to build floating batteries; the plan has often been considered by eminent engineers, and at one time was tried in the harbor of New York, but it is not generally in favor, the idea being that fixed armored batteries, on outlying shoals and islands, are more economical and efficient. If we would substitute floating batteries for vessels of Type I, we must be prepared for a monstrous outlay of funds on coast defences, because we would have to line the whole coast with them, and to repair and replace them at intervals as they deteriorate, the same as with ships. And after all, they could be passed by Type I of the enemy, and we would still feel the need of Type I for operations against an enemy's bases.

I regard torpedo-boats as extremely useful auxiliaries to oblige an enemy, intent on operating against our ports, to adopt cumbersome precautions. As yet we possess none of these useful auxiliaries to which foreign builders have given great attention, and it is probable that experiments performed with them

and experience in handling them will develop changes in their build or armament which we may wish to make. Moreover, they belong to a class of small vessels which, in emergency, could be constructed more readily than the other types to which more space is devoted in the essay; but in their construction I would strictly adhere to the maxim concerning individual superiority or equality, which seems to have met with such general favor.

I think the substitution of a number of Type II for a number of Riachuelos, recommended by Commander Goodrich, would prove a bad policy, and would nourish that false economy incident to a disregard of the object upon which I have laid so much stress in the groundwork of the essay. The Riachuelo, although a peer among many ships of the present day, is a compromise between Types I and II, and in comparison with the ships which we could build she would be ill-adapted to perform the services assigned to either type. The battle-ships should have no peers at sea, and the coast defenders should have no superiors in port. The new ships we are praying for exist, as yet, in the imagination only, and I think they should be designed to engage those of other nations, of the same type, which will be launched when they are launched, rather than those which are afloat to-day. In the words of the essay: "If, then, it is not possible or even necessary for us to possess a very large fleet, great care and sagacity are required to maintain the fleet we do possess in a condition thoroughly adapted to the requirements of war, so that it may be efficient when required for use."

The substitution doctrine is always fascinating, and apt to lead us, through inviting channels and by apparently short cuts, to dangerous shoals. If there be no limit to it, the same fascinating doctrine might lead us to advocate four Riachuelos of 3000 tons to replace the two of 6000 tons, which had formerly replaced one battle-ship of 12,000 tons; but unfortunately the limit is a stumbling-block which declares that, in the most important cases, the smaller ships, combined or singly, could not do the work of the larger. It is argued, "adapt the tool to the work," but unfortunately our enemies would not agree to match ships for a contest, and we could not always anticipate just when the enemy would call out particular ships; but even if we could anticipate, the substitution policy would deprive us of a certain number of the right tools when the call came for battle-ships. The Riachuelo, with 15 knots and 9-inch guns, might render a good account of herself in action with many vessels afloat to-day, but there would still be the greater chance of giving a different account of herself in action with a battle-ship of the future, with 20 knots and 15-inch guns, excelling her in protection, endurance, steadiness of gun-platform, stability, seaworthiness and habitability.

While agreeing that occasions may arise when the smaller ships, owing to increased numbers, may perform more efficiently the duties of a larger class, I regard it as exceedingly dangerous to foster the idea with regard to battle ships. This idea, if encouraged, would result in one of two evils; we would either have a certain number of battle-ships substituted by the *same number* of Riachuelos, or some of each class would remain inactive throughout their ages of efficiency, and, consequently, would be inefficient, to a certain extent, when

required for use. The reason is explained at length in the essay. It is probable that the battle-ships would be neglected altogether, and we would not be accustomed to their use when the time came. I think we can safely assume that service on board a battle-ship would fit us for service on board of any smaller type of sea-going ironclad.

Commander Goodrich's criticism of my views on the construction of guns gives me the opportunity to explain that this essay was written before the report of the Gun Foundry Board, and in a candid spirit, deeply impressed with the success of private gun-firms in Europe and the conservative blindness of various national gun foundries. Whichever method may be adopted, I hope the government will not neglect to encourage private firms sufficiently to enable them to compete in the outside market, and to interest our civil talent in the details of this industry so important to our national defence.

I see no objections to the use of battle-ships as transports, for minor operations or raids against an enemy's West Indian possessions; and for *extended* operations against an enemy's bases, I think they would furnish powerful mobile bases, supplemented of course by auxiliary supply vessels.

Although I regret that the vastness of the subject and the limitations as to space in the Proceedings have made the essay somewhat obscure in parts, I am pleased to note that Commander Goodrich has misconstrued the meaning of my reference to the probable outcome of an encounter between the Chicago and a torpedo cruiser, for thereby I have gained additional weight for my reply to the criticism of Commander Hoff. The question, "If future actions are not to be fought at long range, ought we not, etc." . . . was simply intended to convince others that the decisive blows of future actions would be fought at long range, and not that the Chicago would have much to fear from a torpedo cruiser bristling with rapid firing and machine guns.

I am glad that Commander Hoff takes exception to the idea of building rams "pure and simple," for I certainly did not intend to convey the idea that I would build such vessels. There is little doubt in my mind, however, that if success in ramming is easy of attainment, and ramming is to be the first resort in action, it would be policy to build vessels in which all other weapons are subordinate. The idea intended to be conveyed was, that in laying down the qualities necessary for our battle-ships, capacity for endurance and speed is so important that it were best to obtain it even at the sacrifice of a certain amount of handiness which is so essential to a ram.

In regard to the "dangerous wake": suppose I have approached so close to my adversary that I cannot turn without danger of being rammed; if I pass him in an opposite direction I am not obliged to turn; but if, after passing, he wishes to close in "bows on," *he* will have to turn, and in doing so will expose his broadside to my torpedoes. If, after passing in opposite directions, he turns towards me under my stern, as laid down in the rules for ramming tactics, I can either have a convenient towing torpedo to give him a warm reception, or I can back astern as he crosses my track, and, by shifting my helm and going ahead at the proper moment, I can get inside of his circle to give him the benefit of both bow and broadside installations of guns and torpedoes, with the greatest advan-

tage to myself if he continues that line of tactics. It seems to me, however, after such an overture it would be folly for both ships to go circling about and doubling each other's tracks, possibly to encounter the wandering torpedoes which might have missed their primary targets, or which might have been dropped overboard on purpose for such an event.

Let us begin the action again, and suppose that when I have sighted my adversary at a distance of four or five miles I turn so that he will bear four points on my bow; if he wishes to shorten distance most rapidly he will take a course at right angles to mine; I can then deceive him as to my intentions by slowing down, if necessary, and can use my guns to best advantage. When he discovers that I have not accepted his tactics he will turn towards me, and I can continue, with safety, to turn away from him and to choose the range at which I wish him to follow. If he follows on my quarter, and I wish to keep him in my wake, I will turn away from him and he will be obliged to cross and recross that wake every time I turn away, and in doing so to traverse a greater distance than I do, owing to the abrupt curves he must make to keep out of my wake. Every time he turns to cross my wake he must expose his bow or broadside to my torpedoes. In pursuing this sort of tactics any increase in the speed of both ships renders my adversary's torpedoes more dangerous to himself, less dangerous to me, and increases the effective range of my torpedoes. If he possesses a superiority of one knot in speed, and succeeds in ramming my stern, his blow will be glancing and harmless. But suppose he has arrived at the only position abreast suitable for ramming in chase; if I stop or go astern, as he puts his helm over, he will cross my bows and give me the best of opportunities for planting my ram plump into his broadside. In other words, it is not only extremely difficult for a chasing ship to attempt to ram, but it is very hazardous, and the destructiveness of a successful blow from astern is very problematical.

In discussing naval tactics, however, and particularly the uncertain phases of the ram, one cannot help feeling that it is mainly speculation; but there are two certain rules which can be laid down: (1) one ship cannot force another to attempt to ram without first gaining some advantage with other weapons; (2) one ship *can* force another to fight at long range, astern or on the quarter, as she chooses. The fact that one adversary can dictate certain lines of action to another, without superior handiness, leads me to conclude that there need be no limit to the size of battle-ships on account of the importance of handiness.

In an engagement between *fleets*, concerted action is of primary importance, and the possession of the weather gauge not only insures a clear understanding of signals, but gives great advantage in properly executing manœuvres; and I think Commander Hoff will agree with me, as most tacticians do, that a stem to stem, or bow to bow, encounter would result in glancing blows or would prove barren of results, so far as injury to the hull is concerned. Similarly, a bow to stern encounter would be quite as unprofitable if the stern attacked were properly protected; and if a following fleet, *A*, were allowed to get so close that it would be hazardous for the leading fleet, *B*, to turn, a preconcerted slowing, stopping or backing manœuvre on the part of *B* would then

render ramming blows glancing and harmless. After the fleets have passed through each other, a turning manœuvre on the part of *A* is required, if his bows are to be presented again, in executing which *A* is in danger, and if *B* does not choose then to ram, the fleets will again pass through each other, bow to bow, with glancing blows.

If ramming were attempted too early or too indiscriminately in fleet engagements, a mass of accidents would follow, friend would injure friend, and victory would soon be left to chance. The impossibility of being able at once to see everything and to be thoroughly protected from machine gun fire at close quarters, should remind a commanding officer, however confident of his skill as a ramming tactician, that a too hasty resort to the charge, *à la Balaklava*, would deprive him, at the critical moment, of the chance to exercise that skill. A commanding officer who decides to try his skill at long range, before resorting to the more furious attack at close quarters, will diminish his chances for a "glorious death," but will deserve the more credit and praise in victory.

The Huascar hesitated about ramming the Esmeralda because it was supposed the latter was defended by torpedoes; and furthermore, it was not until after the Esmeralda's engines were disabled that the Huascar, after several unsuccessful attempts, finally succeeded in ramming.

In the duel between the Buvet and Meteor, off Havana, during the Franco-Prussian war, the Frenchman steered straight for his antagonist at full speed; the German slowed down, trained his guns, and waited bows on. The Frenchman struck a harmless glancing blow, which slewed the guns around, and the German disabled his adversary's engines, in passing, by a well directed shot. The top-hamper which fell from aloft, however, fouled the German's screw and allowed the Frenchman to make sail and to escape into Spanish waters.

I also differ with the authority quoted by Commander Hoff as to the future effectiveness of mobile torpedoes. I do not say that the Whitehead will be effective at more than 200 yards at sea, although it is probable it will continue to make further strides of improvement; but I do think that a torpedo, discharged with low velocity, and afterwards impelled by a self-contained charge of rocket composition, can be made more effective, less expensive, and less complicated than the Whitehead. The medium through or over which it moves will surely not cause its flight to be more erratic than it formerly did the flight of smooth-bore common shell, which often did the best execution when fired *en ricochet*. It would not be difficult, under the stimulus of the proper investigation and experiment, to perfect an elongated ricochetting projectile provided with a suitable tail for accuracy, and a mechanical contrivance for dropping and exploding the torpedo contained, on impact.

The details would be a matter of cheap experiment, and this view of the question is in accordance with what I regard as the chief spirit of the essay, *i. e.* if we begin to expend a few dollars annually on original experiments to encourage our American inventive genius, we will be able to solve important questions for ourselves, and will not be dependent on the ideas or led into the mistakes of others.

In conclusion, I desire to express my thanks for the kindly spirit with which

my essay has been received; but if there be any to whom the opinions expressed appear presumptuous or egotistical, indulgence is asked and zeal is pleaded as an excuse. The need of a vigorous progressive policy is acknowledged, and I sincerely hope that those who still differ with me in any of the details of the plan for reconstruction, may be induced to elaborate their views and submit them for further discussion by the Institute. It is important that many of the details should be more exhaustively treated, and such contributions can never fail to arouse the interest of those who desire again to see our flag proudly float over ships worthy of its honor.

NAVAL INSTITUTE, ANNAPOLIS, MD.

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NOTES ON THE LITERATURE OF EXPLOSIVES.*

Prof. Charles E. Munroe, U. S. N. A.

No. VII.

Through the courtesy of Col. V. D. Majendie, C. B., H. M. Chief Inspector of Explosives, we are in receipt of the *Seventh Annual Report* (1882) *of H. M. Inspectors of Explosives*, and of several special reports of the circumstances attending some recent cases of explosion. The number of factories (exclusive of "toy" fireworks factories) is now one hundred. The following explosives have been added to the licensed list:

E. C. Sporting Powder.† Consisting of rifle gun-cotton, with the addition of coloring matter consisting of aurine (free from mineral acid) dissolved in a solvent composed of ether, alcohol and benzoline.

E. C. Rifle Powder. Consisting of rifle gun-cotton, with the addition of coloring matter consisting of picric acid (free from mineral acid) dissolved in a solvent composed of ether, alcohol and benzoline.

Asphaline No. 1. Consisting of a mixture of chlorate of potash and bran, as hereinafter defined, with or without an admixture of one or more of the following ingredients, viz. nitrate of potassium, sulphate of potassium, paraffin oil, paraffin, ozokerit (such paraffin oil, paraffin and ozokerit to be free from mineral acid), soap, fuchsine; such mixture to contain not more than 54 parts, by weight, of chlorate of potassium, and four parts, by weight, of nitrate of potassium and sulphate of potassium, or either of them, to every 42 parts, by weight, of bran.

* As it is proposed to continue these Notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars.

† These Notes, 10, 221.

Bran, consisting of wheat bran or barley bran, thoroughly cleansed and reasonably free from flour.

Asphaline No. 2. Consisting of asphaline No. 1, as above described, with the addition of nitrate of potassium in such proportion that the total amount of nitrate of potassium present shall not exceed 25 parts, by weight, in 100 parts, by weight, of the finished explosive.

Spon's Electric Fuses. Consisting of a case of metal, wood, paper or other suitable material, containing two or more insulated wires, the terminals of which are (*a*) imbedded in a charge not exceeding five grains of one or other of the priming compositions (1) (2) (3) hereinafter specified, or (*b*) connected by a bridge of fine wire, composed of a platinum alloy, steel or other suitable material, the said bridge being imbedded in a charge not exceeding ten grains of one or other of the priming compositions (4) (5) hereinafter mentioned.

Priming composition (1), chlorate of potash and sulphide of antimony, with or without powdered carbon.

Priming composition (2), chlorate of potash, sulphide of antimony and phosphide of copper.

Priming composition (3), chlorate of potash, sulphide of copper and phosphide of copper.

Priming composition (4), gun-cotton thoroughly purified.

Priming composition (5), gun-cotton thoroughly purified, chlorate of potash and powdered galls.

Spon's Electric Detonator Fuses. Consisting of electric fuses, as above described, and having attached thereto a detonator, as defined by an Order in Council made under the 106th section of the Act.

Hunter's Patent Miners' Fuses. Consisting of a cylindrical tube of paper, varnished or coated with a suitable waterproof solution, and filled with gunpowder, in the proportion of not more than one pound of gunpowder to every five hundred fuses, the paper tube being closed at both ends, and having one end primed with a solution of nitrate of potassium or nitrate of sodium, or with melted sulphur, with or without nitrate of potassium.

Miners' Squibs. Consisting of a tube of paper, or other suitable material, partly filled with gunpowder in the proportion of not more than one pound of gunpowder to every five hundred squibs, and having one end closed with a plug of wax, or other suitable material, and the other end closed by being twisted, and such twisted end being coated with sulphur or not so coated.

Sound Signal Rockets. Consisting of a signal rocket having fitted

in the head thereof one or more charges of tonite * or cotton-powder as hereinafter described, and with or without a layer of compressed gunpowder made of sulphur (free from acid), saltpetre, and charcoal, between the said charges, and having imbedded in the said charges one or more detonators as defined by an Order in Council, made under the 106th section of the Act, such detonators to contain above the fulminate a substantial layer either of strongly compressed mealed gunpowder or of a composition made of two or more of the following ingredients, viz. saltpetre, sulphur (carefully washed), realgar, antimony, gunpowder. The said tonite to consist of gun-cotton thoroughly purified, mixed, or incorporated with a nitrate or nitrates.

Distress Signal Rockets. Consisting of sound signal rockets as above described, with the addition in the head of the rocket of one or more stars composed of two or more of the following ingredients, viz. saltpetre, sulphur (carefully washed), realgar, antimony, gunpowder.

The name of the explosive designated as *Liverpool Cotton Powder* or *Potentite* was changed first to *Potentite Cotton Powder*, and subsequently to *Potentite*. Potentite (which is nitrated gun-cotton) is manufactured by the Potentite Co., at Melling. Certain specimens of their product were found to be so impure that they were warned.

The importance of putting dynamite in waterproof envelopes, for transportation, is illustrated in the case of the sinking of a barge, where the water reached the dynamite and expelled the nitro-glycerine. Again, in 1882, a case of dynamite was being conveyed across the Duddon Sands. The driver of the cart, trying to make a short cut, got into a quicksand, when the water reached the dynamite and caused the exudation of a large quantity of nitro-glycerine.

A new illustration of the failure of prohibition to prohibit is the following: The railway companies have refused to carry dynamite and some other explosives of that class under any conditions, notwithstanding the remonstrances of the Inspectors of Explosives. Hence it is not surprising to learn that an agent of the Nobel's Explosive Co. was found to have carried no less than 300 lbs. of blasting gelatine on a passenger train from Newcastle to London, across London in a cab, and thence by rail to Whitstable. The explosive was packed in soft leather bags, a portion of them being taken in a smoking-car, and the rest as ordinary passenger luggage in the van.

* These Notes 9, 754.

The importations of dynamite for the year amounted to 1,008,050 lbs. With two exceptions this dynamite satisfied the required tests. The first was a cargo of 22,200 lbs., from Krebs & Co., of Cologne, made from very imperfectly purified nitro-glycerine. The second, of 75,000 lbs., from Nobel's Explosive Co., Hamburg, was made of nitro-glycerine of satisfactory purity, but the kieselguhr was strongly and dangerously acid. An importation of "Forcite" from Spain was prevented, as examination showed it to be an explosive which had never been examined or tested in England, and of whose properties the inspectors were ignorant. The importation of fulminate of mercury amounted to 12,400 lbs., and of detonators to 1,075,000 lbs.

The report of Dr. Dupré, chemist, to the Home Office, shows that the blasting gelatine submitted to him was in every case rejected, as showing a tendency to exude nitro-glycerine, while in addition, in some cases, the cartridges were of a soft or semi-fluid character, which became very marked at 80° F., thus defeating the *main* object of its manufacture, namely, the conversion of a *liquid too dangerous* to use on *account* of its being a *liquid* into a *solid*, comparatively safe explosive, *safe because* it is *solid*.

Samples of colored fires and fireworks were examined, owing to an accident at Stoke, and it is stated that the presence of sulphur in a chlorate mixture, even when the sulphur has been carefully washed, is a source of danger. Mixtures containing sulphur and a chlorate are exceedingly sensitive to percussion and friction. It is recommended that potassium perchlorate be substituted for the chlorate, as suggested by a German periodical. The sensitiveness to percussion and friction is thus diminished while the brilliancy is increased. Experiment showed that a one-pound weight falling 10 to 12 inches exploded a mixture of potassium chlorate and sulphur, while a fall of the same weight through 18 to 20 inches was required to explode a similar mixture of perchlorate. Moreover, while the chlorate mixture exploded completely at the first or second blow, it required from five to seven blows to entirely explode the perchlorate mixture. The substitution of the perchlorate would also, probably, diminish the danger of spontaneous ignition of sulphur mixtures, since not even oil of vitriol decomposes perchloric acid.

Experiments made with mixtures of filings or borings of iron or steel, with sulphur, showed that when moistened with water and surrounded by bad conductors of heat, or in insufficient mass, the temperature rose rapidly, much steam was evolved and the mixture

became in some cases red hot. This would seem to show that Gerbe mixtures were liable to spontaneous ignition, but in fact the danger is believed to be slight, since the iron borings used are generally very coarse, and since charcoal and nitre are also added. The points of contact of iron and sulphur are therefore limited, in consequence of which the amount of chemical action which can take place in a given time is but small, and but little heat is evolved. In several experiments with recently made Gerbe mixtures the maximum elevation after moistening was 5° F. When, however, the coarse iron borings were extracted from this mixture by a magnet, and replaced by an equal weight of fine filings, the temperature rose in a few hours as much as 45° F. This would not be enough to endanger the stability of the mixture, but would seriously endanger the safety of a star of sulphur and a chlorate imbedded in it. Iron filings and nitre when moistened likewise increased in temperature with oxidation of the iron and reduction of the nitrate to nitrite. The action, though beginning very soon, is far from energetic, and the rise in temperature is only 5° F.

The influence of temperature on the sensitiveness of dynamite to percussion was tested, showing, as was to be expected, that warm dynamite was more sensitive than cold. One grain of dynamite, at a temperature of 60° F., required a fall of a one-pound steel weight through 18 inches to explode it, while similar quantities at a temperature of 200° F. were exploded by the same weight falling through 9 inches. Similar differences had previously been found with gun-cotton and Schultze gunpowder.

In analyzing an impure nitro-cellulose, the insoluble residue, after extraction with alcohol and ether, exploded spontaneously, while drying in the water oven.

Experiments on the inflammability of moistened tonite showed that with 8 per cent. of moisture tonite could be set fire to and would continue to burn. With 10 to 11 per cent. it is uninflammable. This is considerably less than is necessary for pure gun-cotton, which requires from 18 to 20 per cent.

Two new explosives were examined—asphaline (given above) and virite. Of the latter there were two kinds. Virite No. 1, a mixture of nitro-glycerine, potassium nitrate and charcoal, passed all the tests successfully. Virite No. 2, containing sodium nitrate in place of potassium nitrate, failed to hold the nitro-glycerine under all the conditions of the tests.

This report contains an admirable summary of the accidental and intentional explosions which have occurred during the year, and much other information to be referred to hereafter.

Special Report No. 48, January 19th, 1883, by Colonel V. D. Majendie, is "On Two Explosions at the Factory of the Explosives Company (Limited), at Pembrey Burrows, Carmarthenshire." The license for this company was granted July 25th, 1882, after the factory had been previously inspected by Colonel Majendie and Captain Cundill. The process employed for making the nitro-glycerine was that invented by Boutmy, and which has been in operation at Vonges since 1872. The license permitted the nitrating of 1500 lbs. of glycerine at one charge. The first explosion took place on the 11th of November, 1882, in the converter. The nitration had been started the day before, and at the time of the accident all but 500 or 600 lbs. of the nitro-glycerine had been removed. The men then drew off the acid until the remaining nitro-glycerine reached the lower tap. Several vessels of this nitro-glycerine were then drawn off, and while the men were busy storing these vessels in another room, the nitro-glycerine left in the converter exploded. It was stated by a workman, who left the building about five minutes before the explosion, that the fumes from the nitro-glycerine were quite exceptional, and that they had nearly choked him as he drew it off. Colonel Majendie finds the cause to be due to violent chemical action established through the decomposition of the nitro-glycerine by the acid present, and cites several previous cases of explosion believed to be due to the same cause. It is noticeable, however, that in all the cases cited, where details are given, it is shown that the action was superinduced by foreign matter, such as water, straw and the like, coming in contact with the acid mixture, and in the case under consideration the apparatus was so constructed that it was possible for foreign matter to get into the converter. In addition Dr. Dupré reports that the glycerine used at Pembrey was impure and not well adapted for the manufacture of nitro-glycerine. It had a rather dark color, a feebly acid reaction, and gave a strong precipitate with nitrate of silver. When mixed with strong sulphuric acid it became very dark and evolved a disagreeable odor. It contained:

Fatty acids about	0.5 per cent.
Fat	0.3 "
Chlorine in form of chlorides,	0.15 "
Water	5.00 "

Besides, no precautions were taken to secure nitric acid free from nitrous acid. While the presence of strong acid will cause the decomposition of pure nitro-glycerine, as has long since been pointed out, it does not seem necessary to look for other causes when we find, as in this case, that the materials employed in the manufacture were impure.

After describing the Boutmy process as used at Vonges, Colonel Majendie states that it "will be found more fully and elaborately explained" in the *Proc. United States Naval Institute*, **5**, 5, 1879. In criticising, however, our omitting to point out the weaknesses of the process, he mistakes a narration for advocacy, and overlooks the fact that the source of the information is quoted.

The second explosion at Pembrey occurred during the thawing of frozen dynamite; and while the cause is obscure, it is thought to have been due to the falling of a zinc scoop or zinc tray into a metal-lined box containing dynamite, which was probably warmed from the thawing process. Seven persons were killed and one wounded in this explosion, while no one was injured in the first explosion.

Special Report No. 55 is by Colonel Majendie and Captain Cundill, and describes the "Circumstances attending Two Explosions which occurred on the Underground Railway, London, on the 30th October, 1883." These explosions took place near the Praed Street Station and at a point between the Charing Cross and Westminster Stations. The first explosion occurred in a tunnel, about 138 feet distant from the station, as the 7.52 P. M. train was passing. The damage in the tunnel consisted in a vertical crater in the wall about 12 inches high, 13 inches wide and 4 to 6 inches deep. Immediately below this crater and extending about 15 inches along the wall, was a horizontal crater about 6 inches deep, partly in the ballast and partly in the brick footing of the tunnel. The flinty ballast in this crater was considerably splintered and the brick footing pulverized. A two-inch gas pipe ran along the wall at a height of 10 inches; a length of this, measuring 14 feet, was blown away, one end being much torn and twisted, and the whole piece bent into the form of a bow. At a distance of 15 inches from the wall, and parallel with it, was an iron switch-rod consisting of a 1¼ inch gas pipe supported on iron rollers at the level of the rails, from which it was distant 2 feet 9 inches, the rollers being fixed on a wooden plank laid on the ballast. The board had about 4 feet of its length blown to splinters, and a large piece thrown upon

the rail, and some of the wheels of the train passed over it. A length of the switch-rod, measuring about two feet, and corresponding exactly with the portion of the gas pipe which sustained the maximum injury, was blown out, the central part of this detached portion being split up and torn. This piece of switch-rod also bore marks of the wheels upon it. A telegraph cable running along the wall at the height of 8½ feet was cut by the explosion. The walls of the tunnel were scored somewhat by the sharp debris blown against them, and the end of a sleeper opposite the crater, but partially protected by the ballast in which it was imbedded, had a number of pieces of splintered stone driven deeply into it. The rails were entirely uninjured.

The injury to the passing train was confined principally to the two last carriages of the six composing the train. In these the greater part of the glass was broken into small fragments, panels and partitions were shattered, the roofs and floors disturbed, the footboards broken, and the carriages seemed to be completely wrecked, yet no part of the framing or running gear was injured.

The gas throughout the train was extinguished, yet the apparatus was found to be uninjured. It is interesting to note that the injury to the train was not confined to the side on which the explosion took place, but extended also to the opposite side, and in the case of one carriage the damage was most marked on that side; 62 persons were injured by cuts and contusions from the pieces of glass and debris, and in one or two cases by *fracture of the drum of the ear* and by severe shocks. Five of the injured were confined in the hospital for a considerable time. The breaking of the glass and putting out of the gas occurred on the surface at the openings of the tunnel for a distance of 350 feet.

The second explosion, which occurred almost simultaneously with the first, took place at a point 24 yards from Charing Cross and 488 yards from Westminster. As it occurred opposite a bay, the only damage done was the breaking of glass and the extinction of gas in both stations; the injuring of the telegraph and telephone wires for about 60 yards; the formation of a crater in the ballast, measuring 3 x 4 inches wide and 1 inch deep; and the "patting" of the walls of the tunnel on the side of the explosion for some little distance to the right and left of the crater, and on the opposite side for a somewhat greater distance. The rails were entirely uninjured, but the ends of the sleepers near to which the explosion occurred sustained some injury.

Three hypotheses were suggested as to the nature of the explosive, viz. coal gas, gunpowder and dynamite. The fact that all the gas apparatus was found intact disposed of the first; the absence of all residue and the extremely local and brusque action of the explosion testified unmistakably to the use of an agent possessing greater detonative energy than gunpowder, while these properties are characteristic of dynamite. The finding a piece of Bickford safety fuse and fragments of copper, presumably from a detonator, strengthened this belief. Accepting this theory, experiments were made by Colonel Majendie, together with Professor Abel and Dr. Dupré, to determine the amount of dynamite necessary to produce the observed effects, the switch-rod and gas pipe from the Praed Street tunnel being used in similar positions to the charge which they bore there, and it was found that two pounds of ordinary dynamite would be sufficient, if properly detonated. The circumstances surrounding the explosions, however, indicated that a larger amount, probably five pounds, had been used, but that a portion had burned without explosion.

The explosion was probably induced by the use of a fuse of such a length as would burn for the desired time. This was then attached to a detonating cap and the latter inserted in a zinc case containing the dynamite. The assassin then boarded a passing train, and lighting the fuse threw the contrivance from the window, the fuse being timed to explode the cartridge under the train following. In the case of the Praed Street train the explosion was premature, and occurred under the train in which the assassin was. In the second case the explosion occurred at the time designed, but the train for which it was intended was late; in one minute more the train would have reached the spot.

In manufacturing processes in chemistry considerable loss ensues where the process must be arrested from time to time in order to permit of the charging or discharging of the apparatus; hence efforts are constantly being made to devise apparatuses and methods by which the processes may go on continuously. Such a method has now been invented by W. N. Hill, for the manufacture of nitro-glycerine, and for which *U. S. Letters Patent No.* 262,769 have been issued. Without the aid of drawings it is difficult to describe the apparatus, but it will suffice to say that it consists of two converters, with acid and glycerine tanks attached, a separator and receivers for the nitro-glycerine and spent acids, all connected by tubes so that the

contents of one may flow to the other. The use of two converters admits of the conversion taking place by successive stages, while weaker acid may be used in the earlier stage. The separator is so arranged as to help materially in controlling the speed of the operation, while by the position of the receivers relatively to the separator we can easily see how the process is progressing at any given time. Of course proper arrangements are made for promoting the mixing of the ingredients and cooling of the mixtures.

Mr. George M'Roberts, F. C. S., has favored us with a copy of an excellent resumé presented by him to the Philosophical Society of Glasgow, April 25th, 1883, under the title "Notes on Nitro-glycerine, Dynamite and Blasting Gelatine," from which we learn that at low temperatures blasting gelatine freezes into a hard whitish solid of crystalline structure; but the exact temperature at which freezing takes place has not been ascertained, as cartridges are sometimes found to resist freezing for 24 hours, although kept during that time in a mixture of ice and salt. Other cartridges are found to freeze readily at about 35° to 40° F. Frozen gelatine is in some respects more easily exploded than unfrozen gelatine. A rifle bullet can be fired through any number of unfrozen gelatine cartridges without exploding them, but when a shot is fired similarly through frozen cartridges they never failed to go off. In this respect blasting gelatine behaves exactly the reverse of dynamite. The transmission of detonation through blasting gelatine when unfrozen is much more slow than through either nitro-glycerine or dynamite, but when the cartridges are frozen the detonation appears to be quite as rapid as in dynamite. It has been lately sought to use blasting gelatine in shells, but the material in its present form does not appear to be well adapted to such a purpose. In order to render it less sensitive, so that the shell might be fired from the gun without risk of exploding the charge, the gelatine had incorporated with it about 3 to 5 per cent. of camphor. The camphor had the effect of rendering the gelatine so insensible to shock that even the blow of the shell against an iron target failed to set it off, and the gelatine was gathered up in bits all around the target. The effect of increasing the proportion of nitro-cotton in gelatine, and diminishing that of nitro-glycerine, is to lessen its sensibility to explosion; and gelatine made tough with 9 or 10 per cent. of nitro-cotton cannot be got to explode with a detonator containing 12 grains of fulminate of mercury and chlorate of potassium.

On the other hand, when gelatine is made of a viscid consistency—such that a cartridge, when deprived of its wrapper and allowed to stand on a porcelain plate, begins to spread itself out—the ordinary detonator in use for exploding dynamite never fails to explode it.

When 10 grams of explosive were fired, with a fuse and detonator, in a pendulum mortar, the following results were obtained:

	Foot pounds.
Blasting gelatine, consisting of 93 per cent. of nitro-glycerine and 7 per cent. of nitro-cotton,	1400
Nitro-glycerine,	1270
No. 1 Dynamite,	900
No. 2 Dynamite consisting of 18 parts of nitro-glycerine, 71 parts of nitrate of potash, 10 parts of charcoal, and one part of paraffin,	531
Westquarter factory mixture for detonators, consisting of 70 parts fulminate of mercury and 30 parts $KClO_3$,	481
Gun-cotton,*	462
Fulminate of mercury,	307
Curtis and Harvey's extra strong gunpowder,	272

The method of testing explosives described above is applicable only to those that detonate, or, in other words, to those explosives whose conversion into gas is practically instantaneous. If the explosive is a slow one, such as gunpowder, the projectile may have escaped before the whole charge is consumed; but with detonating mixtures the explosion is so rapid that there can be no doubt that the conversion into gas is complete, even before the projectile has begun to move. The chronoscope of Captain Noble showed that explosion is transmitted through trains of dynamite at the rate of 20,000 to 24,000 feet per second. At this rate the explosion of a cartridge a foot long must only occupy the 24,000th part of a second. A ton of dynamite cartridges of the usual size, about ⅞″ diameter, laid end to end in a line would stretch a mile, and the whole train could be exploded in the one-fourth part of a second by firing a cartridge at either of the ends. If fired in the middle of the line the explosion would be transmitted both ways, and would occupy only the eighth part of a second. The facility with which dynamite can be fired in trains offers great advantage in many engineering operations, such as where it is

* The reason, no doubt, why the gun-cotton shows so poorly in this table is that its explosion in the mortar was imperfect.

required to blow down an arch or a wall. It is enough to lay a train of cartridges along the crown of the arch, or along the bottom of the wall, and explode one cartridge in the usual way with a detonator. The whole train goes off instantly. The enormous velocity with which dynamite explodes explains the great violence of its action, and the tremendous local rupturing effects of even small quantities of it exploded in the open, and without being enclosed in a case of any kind. The detonation of a cartridge in the 24,000th part of a second must produce an enormous instantaneous pressure on the spot on which it explodes. For such a sudden explosion the pressure of the atmosphere itself is sufficient tamping.

The increase in the demand among miners for strong explosives is very remarkable. Since 1867 the annual sales of dynamite from the factories with which Mr. Nobel is associated have been as follows:

In 1867,	11 tons.	In 1875,	3500 tons.
1868,	78	1876,	4300
1869,	184	1877,	5500
1870,	424	1878,	6200
1871,	785	1879,	7000
1872,	1350	1880,	7500
1873,	2050	1881,	8500
1874,	3120	1882,	9500

The last two years have been estimated, as there are no precise figures to go by. The sale of such a large quantity of explosives indicates a considerable amount of mining activity. Besides the factories with which Mr. Nobel is connected, numerous others have sprung into existence, notably in Germany and in America. In Austria dynamite is no longer manufactured, as there is no demand for it, its place having been taken by blasting gelatine.

It is unfortunate that in Great Britain the manufacture and sale of explosives is hampered to a hurtful degree by legislative restrictions. Some restriction is no doubt necessary, but in this country restriction amounts in some cases almost to prohibition, if a new explosive is to be introduced. As the law now stands, if a manufacturer discovers a new explosive or a new explosive mixture, he cannot make working trials of it without the consent of the Home Office, and without having submitted samples for the approval of the Home Office Chemist, to whom, as a matter of course, a fee must be paid. This regulation must interfere with the introduction of a new invention, because no

man will care to pay fees for the examination of an explosive which, when it comes to be tried, may not take with the public after all. Abroad, although there are restrictions affecting explosives, there are no such onerous impediments as here; hence foreign chemists and manufacturers have an advantage in that respect.

The Pennsylvania Railroad Company has issued the following rules concerning the transportation of explosives over its system of lines:

High explosives such as Atlas, Hercules, Giant, Dittmar, Commercial, Ætna, Hecla, and other nitro-glycerine powders, will be received for shipment only under the following conditions:

First. Shipments to be packed in strong boxes, not too large to be readily handled by one person, and each package to be plainly marked "Explosives"—"Dangerous" on top, and on one side or on one end.

Second. It is understood that in these articles the nitro-glycerine is thoroughly absorbed in charcoal, sawdust, infusorial earth, wood fibre, carbonate of magnesia, or other similar substances, and that the amount of nitro-glycerine is such that the temperature of the hottest summer day will not occasion a leakage. Should any package show outward signs of any oily stain, or other indication that absorption is not perfect, or that the amount of nitro-glycerine is greater than the absorbent can carry, the packages must be refused in every instance, and must not be allowed to remain on the property of the company.

Third. Nitrate or other explosive preparations not in accordance with above specifications (except ordinary black powder) will in no case be received for shipment.

Fourth. Shipments must be loaded so as to lie bottom side down, it being understood that the cartridges are so placed in the boxes that they will lie on their sides, and never on their ends when so loaded. The boxes must be so placed in car that they cannot fall to the floor under any circumstances.

Fifth. Shipments of common black powder may be received if packed in good substantial iron or wood kegs. Packages not to exceed one hundred and fifty pounds in weight, unless for export, when larger packages will be received.

Sixth. In no case will percussion caps, exploders, safety squibs, fulminators, friction matches, or any other articles of like nature be loaded in same car with any of the above explosives. There cannot be too great care exercised in this matter.

Seventh. Safety fuse will be received for shipment at any time it is offered, and the restrictions in regard to shipping powder do not apply to it.

Eighth. As the special powder cars will be taken out of this service, agents must know that none of the above explosive substances are loaded at their stations in old cars having loose boards or cracks in the roof or sides. Cars for carrying these explosives must be first-class in every respect, must be tight everywhere, and must have doors that can be closely shut, leaving no crack for sparks to get in. When in full carloads the doors must be stripped.

Ninth. Every car containing any of the above explosive substances, either full carload or small package, must be plainly marked on both sides, "Powder—Handle Carefully," so that those having charge of it will not do anything ignorantly to incur danger. This should be done by the shipper of full carloads and by the agent when the packages are loaded in car at his station.

Tenth. Conductors must not take from any station or siding any car known to contain an explosive substance, unless Rules 8 and 9 have been complied with, and such cars must be placed in their train as near the middle as possible.

The law provides heavy penalties, both to shippers and common carriers, for violation of these rules, and agents should be careful to see that such shipments are put up, marked and forwarded only under their proper names, and in accordance with these provisions.

The *Iron Era*, of Dover, New Jersey, December 22, 1883, contains an account of the opening of the works of the American Forcite Powder Manufacturing Company at Lake Hopatcong on the Morris Canal. The works number upwards of forty buildings covering an area of 450 acres of land, heavily wooded. The buildings, where the powder manufacturing is to be done, are situated from 100 to 200 feet apart, and placed in excavations in the side-hills so that only one side is exposed. All these buildings are lined, ceiled, heated by steam and furnished with water. The nitro-glycerine is carried from the converting house to the mixing house, by gravity, through large India-rubber pipes, well protected and laid under the ground. The converting house is a three-story frame building 32 x 32 feet. The converter is in the third story, the separating tanks and washing tanks are on the lower floors. The spent acid flows through leaden pipes to the acid house, where it is regenerated and forced back to

the converting house 900 feet away. The acid house is of brick, 25 x 65 feet, and contains four large retorts and condensing towers for regenerating the spent acids. The magazines are built in excavations in the hill so that the roofs are below the surface of the ground. The structures are of brick with roofs of corrugated iron. This roof forms a lightning conductor and has rods leading from the four corners into the ground, as in the Belgian government magazines. A system of ventilation, through hollow bricks, allows the air to enter at the bottom and escape at the top. A reservoir capable of furnishing 60,000 gallons of water daily, and an ice house 30 x 50 feet are connected with the works. The concern has a capacity of five tons of powder per day, and beginning with a force of 50 men it is expected to soon increase to 100.

Forcite is described as a hard plastic substance looking very much like India-rubber and as tough. The principal advantages claimed for it are greater safety in handling than other nitro-glycerine compounds possess, and imperviousness to water. It may be exposed to a temperature of 120° without allowing the nitro-glycerine to exude, and may be submerged under water a long time without damage. There are now three factories in Europe making this powder.

U. S. Letters Patent No. 242,783, dated June 14, 1881, and granted to John M. Lewin, of Paris, France, describe "Forcite" and the method of preparing it as follows:

Heretofore nitro-glycerine has been reduced to a gelatinous mass by dissolving gun-cotton or nitro-cellulose therein, and nitre has been incorporated in such mass. In the present invention neither gun-cotton nor other form of nitro-cellulose is required, but the cellulose is used in an unnitrated condition.

In order to carry the invention into effect, cotton or other form of cellulose is treated alternately with alkalies and acids, as in the cleaning of paper-stock, or in any ordinary or suitable way, in order to remove foreign materials and leave pure cellulose. This is then reduced to powder by a picker or grinding-cylinder, and is subjected in a close vessel to the action of high-pressure steam, until the reaction takes place by which the cellulose is converted into a gelatinous mass. At this moment the operation is stopped, the gelatinous mass obtained (which can be preserved indefinitely under water) is allowed to cool, and is then dissolved in or thoroughly and uniformly incorporated with nitro-glycerine, the result being a sort of jelly. The

solution or incorporation is effected by the aid of heat. A temperature of 40° centigrade is suitable, and can easily be obtained by a water-bath in which the water is heated to, say, 90° centigrade. Nitre is incorporated with the nitro-glycerine and gelatinized cotton described to form the new explosive—forcite.

The proportions may vary. One of the best compositions is nitro-glycerine, seventy-five; gelatinized cotton, seven; and nitre, eighteen. Dextrin can be used instead of a large part of the gelatinized cellulose. In such cases the following composition is preferred: nitro-glycerine, seventy; gelatinized cellulose, one; dextrin, five; nitre, fifteen; ordinary cellulose, nine. The ordinary cellulose is, or may be, in the form of powder.

Forcite thus prepared is a plastic mass, having the power of nitro-glycerine, and being attended in its making, carrying and keeping, with less danger than explosive compounds before known, and even than "blasting" or "mining" powder, properly called. It has the remarkable and most advantageous property of exploding when confined or charged in a drill hole, as well as by the action of special primers or caps as by ordinary fuses, and of burning without explosion in the open air. Its manufacture is less costly than other compositions of nitro-glycerine. The nitro-glycerine is so perfectly united with the other materials that it is not separated by sulphuric ether or alcohol, and water has no action upon it. The nitro-glycerine therefore preserves its properties without alteration, even under water.

The *Jour. Chem. Soc.*, January, 1884, contains four interesting articles on the fulminates. The first (p. 13), by E. Divers and M. Kawakita, entitled "On the Constitution of the Fulminates," discusses the work of Carstanjen and Ehrenberg* and of Steiner, and gives the results of their own investigation. They added dry fulminate of mercury† to fuming hydrochloric acid, without danger, and obtained the whole of the nitrogen as hydroxylamine chloride free from hydrocyanic acid. When dilute HCl was used much HCN was given off. By distillation with fuming HCl formic acid was obtained; careful

* Proc. Nav. Inst. 8, 667.

† This operation seemed to involve no danger. The fulminate was free from metallic mercury. The presence of the latter is due to the action being too much checked, in accordance with caution usually recommended. The action should be allowed free course.

search showed neither oxalic nor glyoxylic acid among the decomposition products. The authors then conclude that

$$C_2H_2N_2O_2 + 4H_2O = 2CH_2O_2 + 2NH_3O$$

represents the change which mercury fulminate suffers under the influence of concentrated hydrochloric acid.

On page 19, E. Divers treats of the "Theory of the Constitution of the Fulminates." The knowledge that the fulminates contain two isonitrosyl radicals or their equivalent, and two formic carbons, greatly simplifies the question as to the constitution of fulminic acid and divests the answer of much of its difficulty.

A theory of the constitution of the fulminates must, before it can be accepted, include an explanation of the formation of these bodies; of their capacity to yield cyanogen compounds, and to yield all their nitrogen as hydroxylamine, and all their carbon as formic acid; of their general if not entire disability to give dicarbon decomposition products; of the difficulty in replacing more than half their silver or mercury by another metal; of their reactions with chlorine and bromine, and of their explosive character.

A notice* of four of the formulæ which have been proposed will make apparent the extent to which they each fulfil these requirements of a theory of the subject:

Berzelius's modernized, .	$Ag_2O(AgN)_2C_4N_2O_2$
Kekulé's, ...	$NCCH_2(NO_2)$
Armstrong's, ...	$HO.N:C:CH(NO)$
Steiner's, ...	$HO.N:C:C:N.OH$

The first furnishes an explanation of the explosive character of the fulminates, representing the metal as combined with both nitrogen and oxygen. It also shows a difference in the relations of the two atoms of hydrogen, or of the metal in place of them.

The second also explains, but in a less satisfactory way, the fulminating character of these salts. It shows why cyanogen derivatives are so readily formed from them, and represents half the nitrogen as oxidized and able to become hydrogenized and produce hydroxylamine just as nitroethane can. But it makes a nitroxyl radical to be introduced by nitrous acid, which, as Armstrong and Groves point out, it should not do. It entirely fails to account for the two kinds

* These Notes, 8, 667.

of acid properties the fulminates possess, and allows of only half the nitrogen becoming hydroxylamine.

The third formula explains the dual nature of the acidity, and also the formation of hydroxylamine and of cyanogen compounds. It is interesting as exhibiting the presence of isonitrosyl in fulminates before this had been established by experiment. But it has become open to the objection, through the recent conclusions of Victor Meyer and his school, that nitrosyl does not get introduced into a CH_3 or CH_2-group, and probably its proposer would now reject it himself on that account.

The fourth formula is satisfactory as regards hydroxylamine and formic acid, but it does not make the cause of the explosive character apparent, nor the production of cyanogen compounds very probable, and, above all, it represents the two hydrogens as being of equal value. Besides this, it makes the hydrogen of isonitrosyl strongly basic, although this is not its character in other isonitrosyl compounds. We should expect, too, the formation of glyoxylic acid. Thus,

$$\begin{matrix} C.N.OH \\ | \\ C.N.OH \end{matrix} + 3H_2O = \begin{matrix} CO.OH \\ | \\ COH \end{matrix} + 2H_2N.OH$$

Divers, then, presents a theory of the constitution of the fulminates which he believes agrees with all the known facts. It is that they are formed from (1) an alcohol residue in which the hydrogen has been replaced by metal, and which retains only the carbon and oxygen; and (2) a condensed hydroxylamine residue.

Hydroxylamine is now always formulated as an amine $H_2N.OH$, but between doing this and formulating it as an ammonium hydroxide $H_3N(OH)_2$ there is little to enable us to decide. Its want of odor is, perhaps, in favor of the latter view. But it may quite probably have still another composition. It may consist, like ether, of two molecules condensed into one with loss of a molecule of water, thus:

$$2H_2N.OH = (H_2N)_2O + H_2O,$$

That is, there is no known reason why $(H_2N)_2O$ should not be the composition of hydroxylamine, oxyammonia, or *amidogen oxide*, its derivatives being related sometimes to this condensed form, sometimes to its simple or alcoholic form of amidogen hydroxide. There is at least evidence of the existence of the condensed or oxide form, in the action of hydrochloric acid on hydroxylamine.

For these reasons Divers gives the following formulas for the fulminates:

$$\begin{array}{l}AgO\overset{}{C}{=}N\\ \;\;H\overset{|}{C}{=}N\end{array}\!\!>O \qquad Hg<\begin{array}{l}OC{=}N\\ \;\overset{|}{C}{=}N\end{array}\!\!>O$$

$$\begin{array}{l}HOC{=}N\\ \;H\overset{|}{C}{=}N\end{array}\!\!>O \qquad \begin{array}{l}NaOC{=}N\\ \;Ag\overset{|}{C}{=}N\end{array}\!\!>O$$

and proceeds to consider their sufficiency for expressing the facts. First, as to formation. The alcohol yields two-thirds of its hydrogen to the oxygen of the nitrogen trioxide and its carbons unite with nitrogen.

$$\begin{array}{l}H\,.\,OCH_2\\ \;\;H\overset{|}{C}H_2\end{array} + \begin{array}{l}ON\\ ON\end{array}\!\!>O = \begin{array}{l}HOC{=}N\\ \;H\overset{|}{C}{=}N\end{array}\!\!>O + 2H_2O$$

The fulminic acid here represented will either only be thus formed in the presence of mercury or silver nitrate, or it will be a transition body which would at once decompose but for the presence of the mercury or silver nitrate, with which it at once undergoes double decomposition, in virtue of being a cyanogen derivative, and just as the otherwise unstable hydrogen cyanide would do in similar circumstances. It is well known, on the authority of Liebig,* that nitrogen trioxide, passed into an alcoholic solution of either mercury or silver nitrate, precipitates fulminate without evolution of gas.

Secondly, as to the character of the metallic or basic element of their constitution. The formation of fulminates under the operation of mercury or silver nitrate, and the displacement of only half these metals from their fulminates by the action of soluble chlorides, are facts in entire agreement with what we know of the cyanides of these metals. Hydrocyanic acid decomposes strongly acid solutions of mercury and silver, and potassium cyanide is decomposed even by the oxides of these metals, as every chemist knows, and their cyanides give stability to the unstable alkali cyanides when combined with them.

Thirdly, as to their explosive properties. To account for these, the presence together of the constitution of a cyanide and that of an oxygen salt seems fully sufficient. Berzelius' view of the matter resembles this explanation, allowance being made for the state of chemistry at the time he wrote. Indeed a formula may be given making out, as his does, that the metal is half united to nitrogen and half to oxygen.

* See page 108.

$$\left.\begin{array}{l}\mathrm{HO.C.NH}\\ \quad\;\;\|\\ \quad\;\;\mathrm{C:N}\end{array}\right>\mathrm{O}$$

This formula is compatible with most of the facts; but that of the formation from alcohol is, as regards the transference required of the hydrogen from the carbon to the nitrogen, difficult to explain. Its relation to hydroxylamine is also not very simple.

Fourthly, as to the production of cyanogen compounds in their decompositions. This follows from the nitrogen being directly united to the carbon. The union with hydrogen sulphide (Steiner) may take place in this way,

$$\left.\begin{array}{l}\mathrm{HO.CN}\\ \quad\;\;|\\ \;\;\mathrm{HCN}\end{array}\right>\mathrm{O}+\mathrm{H_2S}=\begin{array}{l}\mathrm{HO.CN.OH}\\ \qquad|\\ \quad\mathrm{HCN.SH}\end{array}$$

This becomes, in presence of water,

$$\left.\begin{array}{c}\mathrm{HOCN}\\ +\\ \mathrm{HCN}\end{array}\right\}+\mathrm{S}+\mathrm{OH_2}$$

and then with a second molecule of hydrogen sulphide,

$$\mathrm{HOCN}+\mathrm{H_2S}=\mathrm{HSCN}+\mathrm{H_2O},$$

besides $$\mathrm{HOCN}+\mathrm{H_2O}=\mathrm{CO_2}+\mathrm{NH_3}$$

and $$\mathrm{HCN}+\mathrm{S}=\mathrm{HCNS}$$

Gladstone's formation of urea by ammonia and hydrogen sulphide follows from the preceding representation, in which cyanic acid appears, as this would, of course, give urea with the ammonia also present.

Fifthly, as to the formation of hydroxylamine and formic acid. To explain this we have the equation,

$$\left.\begin{array}{l}\mathrm{HOCN}\\ \quad\;\;|\\ \;\;\mathrm{HCN}\end{array}\right>\mathrm{O}+2\mathrm{HCl}+4\mathrm{H_2O}=\left\{\begin{array}{c}\mathrm{HOCO}\\ \mathrm{H}\\ +\\ \mathrm{H}\\ \mathrm{O}\\ \mathrm{HCO}\end{array}\right.+2\mathrm{ClH_3NOH}$$

the $\equiv\mathrm{N_2O}$ taking one molecule of water to become 2 ($=\mathrm{NOH}$), and the $\mathrm{C_2}$ taking another to separate them (as when oxalic acid becomes formic and carbonic acids, and just for the same reason that they are only loosely held together, through all the ethane-hydrogen having been displaced). Each $=\mathrm{CN}-$ takes a molecule of water to separate its elements to form on the one side carbonyl and on the other amidogen, as is usual with the cyanogen radical.

The production of formic acid and other monocarbon compounds only is thus seen to be consistent with the dicarbon constitution derived from alcohol, while the formation of oxalic acid is not very improbable, provided there is a source of oxygen, but Divers and Kawakita were unable to obtain it. The reaction for carbonic acid is as follows in its first stage,

$$\left.\begin{array}{l} Hg<\begin{array}{c} OCN \\ | \\ CN \end{array}>O \\ \\ Hg<\begin{array}{c} OCN \\ | \\ C \end{array}>O \end{array}\right\} + H_2SO_4 + H_2O = \left\{\begin{array}{c} \begin{array}{c} HCN \\ | \\ HOCN \end{array}>O \\ + \\ \begin{array}{c} HOCN \\ | \\ CN \end{array}>O \end{array}\right. + Hg_2SO_4,$$

and then the fulminic acid shown in the upper line yields formic acid, and the lower (transition) acid yields formic acid and carbonic acid by further hydration.

Carbonic acid and hydrocyanic acid are also formed together under the influence of dilute hydrochloric acid. In this case only half the cyanogen of the fulminate undergoes hydration—the half combined with hydroxyl and apparently therefore less stable than the other:

$$\begin{array}{c} HOCN \\ | \\ HCN \end{array}>O + 2H_2O = \left\{\begin{array}{l} (HO)_2CO + H_2NOH. \\ \quad\quad\quad + HCN \end{array}\right.$$

Lastly, as to the action of bromine or chlorine. The primary reaction of bromine to form a body corresponding in composition with fulminic acid, but certainly not in constitution, admits now for the first time of ready explanation, without resorting to intra-molecular transposition,

$$Hg<\begin{array}{c} OCN \\ | \\ CN \end{array}>O + 2Br_2 = HgBr_2 + \begin{array}{c} OCN \\ \\ Br_2CN \end{array}>O.$$

The product cannot on the present view retain its generally accepted name of dibromacetonitril, its carbons being detached. Its conversion into bromopicrin and cyanogen bromide by excess of bromine in alkaline solution, is as intelligible as the formation of bromopicrin by hypobromite in other cases:

$$Br_2 + OCN.O.Br_2CN = BrCN + Br_3CNO,$$

one atom of bromine replacing an atom of oxygen, and by thus leaving three-fourths of the combining power of the carbon to the nitrogen causing this to leave the other oxygen to the other nitrogen. Thus

we get cyanogen bromide. Then the oxygen displaced by bromine acts in the form of hypobromite as an oxidizing agent on the NO, changing it to NO_2, the second atom of bromine combining with the carbon now only a quarter united to nitrogen.

In a "Note on the Formation and on the Constitution of the Fulminates," page 25, H. E. Armstrong states that the formula proposed by him was first publicly mentioned April 1, 1875, in the course of some remarks on Steiner's paper "On the Action of Ammonia and Sulphuretted Hydrogen on the Fulminates." His reasons for dissenting from Kekulé's formulas are stated in *Miller's Elements of Chemistry*, 3, 176, 5th edition. In proposing an alternative formula he was led to assume that half the nitrogen was present in the form of nitrosyl, NO, and the other half in the form of *hydroximide* N.OH, because he took it for granted that the fulminates were the products of the direct action of nitrous acid upon alcohol, it being known from Victor Meyer's researches that both of these groups could be introduced through the agency of nitrous acid; the assumption that the fulminates were nitroso-derivatives also appeared to account for the formation of nitro-trichlormethane on distilling them with bleaching powder, as it was known that certain nitroso-compounds were easily converted by oxidation into nitro-compounds.

But Victor Meyer's more recent researches have shown that the radical NO is not introducible into a CH_3 or CH_2 group by means of nitrous acid. The formula then requires modification, the equation expressing the primary reaction,

$$\begin{array}{l} CH_3 \\ \vert \\ CH_2OH \end{array} + \begin{array}{l} NO.OH \\ \\ NO.OH \end{array} = \begin{array}{l} CH_2.NO \\ \vert \\ C(N.OH).OH \end{array} + \begin{array}{l} OH_2 \\ \\ OH_2, \end{array}$$

being thus far incompatible with our present knowledge as to the action of nitrous acid. Armstrong thinks Divers has made a similar mistake, since nitrous acid, and not its anhydride, must be the active agent, and therefore we may write his equation in the following manner without affecting the formula he deduces:

$$\begin{array}{l} HO.N \\ HO.N \end{array} + \begin{array}{l} CH_3 \\ \vert \\ CH_2.OH \end{array} = \begin{array}{l} HO.N:CH \\ \quad\quad\ \vert \\ HO.N:C.OH \end{array} + OH_2$$

$$\begin{array}{l} HO.N:CH \\ \quad\quad\ \vert \\ HO.N:C.OH \end{array} = OH_2 + O\!<\!\begin{array}{l} N:CH \\ \quad\ \vert \\ N:C.OH \end{array}$$

Here it is assumed that the CH_2 group exchanges 2H for N.OH; a reaction which is as entirely without precedent as that involving the exchange of H in CH_3 or CH_2 for NO under the influence of nitrous acid; the conversion of nitromethane into "methyl-nitrolic acid" might indeed be cited, but can scarcely be regarded as a parallel case.

Whatever may be the force of this objection, Armstrong propounds a different formula on what he considers higher grounds, viz., from a consideration of what is probably the nature of the reaction between alcohol, nitric acid and mercury. In the first place, it is not probable that the fulminate is the immediate product of the action of nitrous acid, however produced, upon alcohol. It is well known that when treated with dilute nitric acid, alcohol undergoes hydroxylation, being finally converted into "ortho-oxalic acid" $C(OH)_3, C(OH)_3$, and Dr. Debus's classical research leaves little doubt that one by one the hydrogen-atoms are displaced by hydroxyl; in this way the alcohol is converted first into "ethaldehydrol" (*Miller's Chemistry* 3, pp. 504, 715, 5th ed.), and then probably into "hydroxyethaldehydrol,"

$$\underset{\text{Ethyl alcohol.}}{CH_3 . CH_2(OH)} \qquad \underset{\text{Ethaldehydrol.}}{CH_3 . CH(OH)_2} \qquad \underset{\text{Hydroxyethaldehydrol.}}{CH_2(OH) . CH(OH)_2}$$

He is inclined to regard this last-mentioned compound as the primary source of the fulminate which is formed from it by the simultaneous—or it may be consecutive—action of nitrous acid and hydroxylamine,

$$\begin{array}{l} HO.NO \\ HO.NH_2 \end{array} + \underset{\text{Hydroxyethalhydrol.}}{\begin{array}{c} H_2C.OH \\ | \\ HC(OH_2) \end{array}} = \begin{array}{c} HO.N.C.OH \\ | \\ HC(N.OH) \end{array} + 2OH_2$$

$$\begin{array}{c} HO.N.C.OH \\ | \\ HC(N.OH) \end{array} = \underset{\text{Fulminic acid.}}{\begin{array}{c} ON.C.OH \\ \diagdown | \\ C(N.OH) \end{array}} + OH_2$$

That hydroxylamine may be formed by reduction of nitric or nitrous acid by ethaldehydrol, or more highly hydroxylized derivatives of alcohol, is in the highest degree probable, especially after Dr. Divers' recent communication on the production of hydroxylamine in the dissolution of metals in nitric acid.

The formula now proposed differs but slightly from that previously brought forward, but it is a far better expression of our knowledge of

the fulminates. The representation of the carbon-atoms as exercising "triad" instead of "diad"* functions removes an obvious objection to his earlier formula.

According to Liebig (*Ann. Pharm.* 5, 287), fulminating silver separates in large needles and without the ebullition of the liquid, when nitrous acid is passed into an alcoholic solution of silver nitrate. Divers and Kawakita have repeated this operation and give their results on p. 27, under the title "On Liebig's Production of Fulminating Silver without the Use of Nitric Acid." There is an improbability of this reaction taking place, since it presents the first example of the displacement of the hydrogen of the $=CH_2$ group by isonitrosyl (—NO—), this having hitherto been effected only in the $=CH_2$ group; and, as another peculiarity, it presents an example of the formation of an isonitrosyl-compound by the action of nitrous anhydride in a neutral solution, instead of in a solution of nitrate at first alkaline and then made acid. It is not surprising, then, that they failed to verify Liebig's statement. They obtained the needle-shaped crystals, but found them to be silver nitrate mixed with a very small quantity of an organic silver salt. There was no fulminate. In fact their experiment in which silver nitrate, alcohol and nitric acid were used, while no nitrous acid was present, gave the best yield of fulminate. Armstrong, p. 27, says of this, that the fact that nothing but an energetic oxidation of the alcohol, by a mixture of nitric acid and either mercury or silver nitrate, seems effective, is entirely in accordance with the view of the constitution which he states above.

From the similarity of copper to mercury and silver in its relations toward nitric acid, as recently discussed by Divers in his paper on "Hydroxylamine," the authors were led to make several trials to prepare copper fulminate from alcohol, and either copper nitrate and nitrogen trioxide; or copper nitrate and nitric acid; or copper nitrate, nitric acid and nitrous acid, but all without success. The active catalytic oxidizing power of cupric salts, which affects the action of nitric acid upon copper (Acworth and Armstrong), and so readily causes the destruction of hydroxylamine (or isonitrosyl hydride), is sufficient to explain the failure. In proof of its being exerted in this case, they state that when nitrogen trioxide is passed for some time into an

* These expressions have reference to the definition of valency which, following Lossen, represents that a radical is monad, diad, triad, etc., according as it is in direct association with either one, two or three radicals.

alcoholic solution of copper nitrate, an abundant precipitation of copper oxalate is produced without any evident activity of the nitrous anhydride, which all along becomes quietly absorbed by the alcohol.

Lieutenant John P. Wisser has translated for *Van Nostrand's Magazine*, **31**, 113, August, 1884, an article by Lieutenant Max von Forster on "Experiments with Compressed Gun-Cotton." The first experiments to determine the efficiency of the explosive were made by placing the cartridges on lead cylinders 46 mm. in diameter (and of various heights) set upon small iron plates lying on solid ground. The wet gun-cotton (containing about 25 per cent. of water) was detonated by dry gun-cotton primers, containing 1 gram of mercuric fulminate, and these were fired partly by electricity and partly by a Bickford fuse. It was first remarked that the cartridges had a greater effect on the short cylinders than on the longer ones, and therefore only the results obtained with cylinders of the same length are compared together. (We may note here that it is not stated whether the cylinders were cast or drawn,* and that the system was not a rigid one.) On making this comparison for some nine experiments, where cartridges of various lengths were employed, the author concludes that in the case of dry gun-cotton no increased effect is produced by increasing the weight of the charge if at the same time the length of the charge is increased, for "it appears that in a long cartridge of dry gun-cotton the upper parts cannot transmit their detonation to the lower parts in the same explosive shock as that effected by the initial detonation of the primer, and hence it follows that in long charges of dry gun-cotton it is better to use several primers, placed some distance apart, and to fire them by electricity, in order to produce the greatest possible effect of the total charge."

When, however, gun-cotton containing 50 per cent. of barium nitrate was used it was found, in comparing cartridges of different lengths, that the effect increased with the weight in the longer ones, but not in a direct proportion, while with dry gun-cotton it diminished in this direction. With wet gun-cotton the effect was still greater than with the nitrated cotton, and it is held that in this substance the explosive wave is propagated with equal velocity throughout the entire length of the cartridge. The character of the impressions made on the cylinders also shows the more rapid action of the wet gun-cotton. Similar results were obtained with panclastite and

* Nav. Inst. Proc. **8**, 664, and **9**, 288.

Sprengel's mixtures. The author claims that these experiments confirm the statements of Abel in *Dingler's Polytechnisches Jour.*, 1874, in regard to the relative rapidity of the propagation of the explosive reaction in wet and dry gun-cotton, and he also extends the comparison to the effects produced.

In the article cited Abel held that "the more energetic action produced when gun-cotton and its preparations are detonated in a moist condition, has furnished the striking proof that the detonation is transmitted the more easily, and the transformation of solid to gas and vapor takes place the more suddenly, the less the compressibility of a given explosive mass subjected to the action of a sufficient initial detonation. Since the water replaces the air contained in the compressed masses, the propagation of the detonation will evidently be favored by the increased resistance which the particles offer during the instant of detonation." Lieutenant von Forster takes exception to this on the remarkable ground that wet gun-cotton is more easily compressed and less compact than dry, a proof given being that when dry compressed gun-cotton is to be reworked it is first moistened in order to facilitate the crumbling. Having passed this criticism the author proceeds to restate as his own, but in other words, the theory of Abel given above.

A most curious and, we believe, entirely original, observation made in these experiments is the fact that when a piece of compressed gun-cotton is detonated on a plate of iron, an accurate impression of the form of the under surface of the gun-cotton is produced. Every angle, every projection and every indentation present in the gun-cotton is impressed on the underlying iron. The author gives an explanation which is as novel as the observation. He holds that the gases produced have copied the form of the gun-cotton and transferred or transmitted it to the iron, "that the gases acting on the iron have occupied exactly the same space, and no more, than the solid explosive previously occupied"; and hence he concludes "that only the gases evolved by the very undermost layer of gun-cotton act on the iron, while the others are lost."

Before meeting with this article of Lieutenant von Forster's we saw similar impressions produced in iron by the detonation of disks of gun-cotton upon the iron,* but we supposed that, as the detonator was placed in the top of the disks, the impression was produced by the lower part of the disks being driven into the iron, just as any other resisting body interposed in the path of the explosive wave

* Van Nostrand's Eng. Mag. 32, 8, Jan. 1885.

would have been. Of course we are met here by the difficulty that this hypothesis implies (1) that the pressure exerted upon the residual mass of gun-cotton is transmitted more rapidly than the explosive reaction is propagated within the mass, and (2) it also implies a great rigidity or coherency for this mass. The last condition is, however, a property of masses of matter when moving at great velocities, as is seen in the well-known candle experiment, and in the cutting of steel by soft iron and the like. The difficulties presented in the first condition do not seem so great as those in Lieutenant von Forster's hypothesis.

From his observations on the effects of the exploding of gun-cotton in drill holes Lieutenant von Forster concludes that its action is more sudden and local than that of dynamite, and he believes that the effect would be increased if we could give the gases of the detonated gun-cotton a fixed direction towards the object. In considering this problem he observes that the explosion takes place in a cartridge in the direction away from the detonating primer, and he finds a marked difference in the results of his experiments when the primer is placed on the end of the cartridge in contact with the target rather than on the end of the cartridge away from the target. He considers the simplest explanation of this fact to be, "that the detonating gases of the primer form, to a certain extent, a dam, so that they offer from the beginning a resistance to the gases generated from the gun-cotton, and thus press them toward the other side. Even a very weak dam of loose earth acts on the gases of the explosive, why not the energetic detonation of the mercuric fulminate?" He also says that "this fact may be explained by the transfer of the vibrations of the gases of the primer to those of the gun-cotton, when the gases of the primer have a fixed direction." Lieutenant von Forster states that the point in the cartridge at which the original direction of the gases is maintained has not yet been determined with certainty, but in his experiments the distance does not seem to be very great; yet in the case of a cartridge of a weight of over double the diameter (*sic*), 70:30, the direction given by the initial detonation becomes quite noticeable. We, too, have observed the difference in effect due to the difference in the position of the primer, but had believed that it could best be explained by Berthelot's theory of the propagation of explosive reactions.*

* Sur la Force des Matières explosives, 1, 73, 1883.

In addition to placing the primer on the side of the cartridge away from the object, the author proposes the use of a cartridge which is hollowed out on the end opposite the primer. In examples given, where cartridges of the same cross-section were exploded on iron plates, the hollow cartridges, although of less weight, produced twice the depth of impression that the solid ones did.

In the second part of his memoir the author treats of his method of rendering gun-cotton impermeable to moisture. Compressed wet gun-cotton has many inherent disadvantages. The water evaporates readily and must be constantly renewed, though this difficulty may be greatly diminished by careful packing and storing; it crumbles easily, and even when well packed may suffer much in long-continued transportation; finally it is subject to the action of a fungus which will in time destroy its structure. The presence of paper in the packages promotes the formation of this fungus and should be carefully avoided. To reduce these disadvantages the author proposes to dip the cartridges in some solvent, such as acetic ether or nitrobenzene, for 15 to 20 seconds, then to take them out and allow the solvent to evaporate. A coating is thus formed on the surface which protects the cartridge from crumbling and prevents fungoid growth. Where an uncoated cartridge will dry in several days, a coated one will require several weeks. Dry gun-cotton cartridges may be treated in the same way, but the author prefers to coat only the cavity for the reception of the primer by this means, and to coat the remainder of the cartridge with melted paraffin. An ingenious application of this invention is in its use for submarine mines, which will remain explosive for a certain fixed time, and after that time will become of themselves inexplosive. This is effected by coating a cartridge so as to render it impermeable and then slicing the coating off from the bottom. When immersed in water the liquid will gradually soak in until the whole is wet and hence inexplosive. The time required is dependent on the length, area, density and composition of the cartridge. A cartridge of pure gun-cotton 100 mm. high and of a density of 1.1 remains explosive for about 8 hours, while in 11 hours it is completely saturated and inexplosive. A cartridge of gun-cotton mixed with saltpetre remains dry for a long time. A rubber tube may be used for protecting the priming.

In explosions under water it often happened to the author that, when the priming cartridge was adjusted by a copper lining, the gun-cotton charge began to burn or "to decompose into dense red fumes,

nitrous acid fumes, etc., but did not detonate. This decomposition of gun-cotton into nitrous acid fumes, etc., by an insufficiently energetic initial detonation of the primer, appears not to have been elsewhere noticed." It seems to us that this observation is not new, though we cannot recall the reference, but we do find it recorded* that when gun-cotton burns from contact with a heated metal the oxides of nitrogen appear among the products.

In treating of the spontaneous decomposition of gun-cotton, the author says that he is in possession of a piece of compressed gun-cotton made in 1878, which was not completely washed and in which some acid remained. The piece was preserved during this time in a chest kept in a dry place. It is now completely decomposed and has become a soft, greenish mass, which has lost the structure and appearance of gun-cotton, and when pressed, yields a glutinous liquid. It smells sour, burns, when ignited, with a white flame (gun-cotton with red flame), and emits no appreciable vapors. No pressure has been observed in the air-tight preserving-jar, in which a part of this experimental prism of gun-cotton has been preserved since the decomposition began. This experiment shows that the spontaneous decomposition of gun-cotton may take place without the production of flame, and the author believes that a spontaneous combustion of gun-cotton has never occurred. Of course, gun-cotton subjected to high temperatures such as can only be brought about artificially, temperatures above 120° C, is not included here. Good gun-cotton is pronounced sufficiently stable for all practical purposes.

How many unforeseen accidents may cause combustion is proven by the following experiment, communicated to the author by Prof. Kraut, of Hanover. If we take a good handful of simple cotton wadding, set a portion of it on fire, and wrap the other part around the kindled point so that the air is excluded, the piece of wadding may be wrapped in paper and preserved for months. If, at the end of this time, the wadding is unwrapped and air admitted, the part kindled months before goes on burning and consumes also the rest of the cotton. How often may this phenomenon have occurred when, in the case of the combustion of ordinary cotton, in large bulk, it was believed to be due to spontaneous combustion? With gun-cotton it is probably often the same.

* Traité sur la Poudre, E. Désortiaux, 2, 647, 1878, and Die explosiven Stoffe, Böckman, 248, 1880.

We must refer to the original paper for the many drawings illustrating the experimental results.

The current press reports that Edison has proposed the use of a detonating mixture of hydrogen and oxygen for war purposes. He fixed two platinum wires, separated by a short space, in a thick glass tube; filled the tube nearly full of water and then sealed it hermetically. The wires were then connected with a dynamo machine, the current made and the water decomposed by electrolysis, by which means an enormous pressure was developed, which was sufficient to produce an explosion. He claims that this explosive is portable, cheap and safe, since the glass and its contents are absolutely non-explosive until contact is made, and he proposes it for use in the place of powder, in guns, in blasting and for torpedoes. For the latter purpose the tube may be buried in the ground, and after connecting the wires with a small battery the current may be so regulated as to explode it in a day, a year, or even ten years.

Under the title "Über die Analyse der Sprengstoffe," Dr. W. Hampe has reprinted from the *Zeitschrift für das Berg-, Hütten- und Salinenwesen*, **31**, 1883, a summary of the various processes proposed and in use for the analysis of explosive substances, to which he adds a method of his own devising. It is impossible to repeat the descriptions here without reproducing some of the many figures of apparatus which the pamphlet contains, and we must content ourselves with calling the attention of those who have such analyses to make, to the work.

To the courtesy of Captain Philipp Hess, of the Austrian Engineers, we are indebted for a copy of his report of the German Health Exhibition of 1883, under the title "Hygiene und Rettungswesen mit Bezug auf die Explosivstoff-Industrie." The topics treated of are: 1. General description of explosive substances; 2. Methods for analyzing and testing the stability of explosives; 3. The construction and arrangement of factories and magazines for explosives; 4. The precautions taken against the dangers inherent to the explosive industry; 5. The literature of the subject. This paper forms an excellent supplement to Hampe's, mentioned above, as it gives methods for testing in the laboratory the condition of stability of these substances. It is very full, too, in its descriptions of safety lamps,

thermometric and electric alarms, fire extinguishers and the like, while it contains over sixty excellent illustrations of the apparatus and devices described. The pamphlet is a reprint from the *Mittheilungen ü. Gegenstände des Artil.- u. Genie-Wesens*, and is dated Vienna, 1884.

M. Pétry has devised the following process for manufacturing the explosive paper which he calls dynamogen.* In an enamelled pot containing 150 grams of pure water he dissolves 17 grams of yellow prussiate of potash, and, when it is heated to boiling, adds 17 grams of charcoal, stirring the mixture well together. Allowing the whole to cool somewhat, he adds, successively, 35 grams of potash, 70 grams of chlorate of potash, and 10 grams of starch, triturated in 50 grams of water. The whole is stirred so as to constitute a very thin paste, which is spread with a brush over ordinary filtering paper. The paper is dried upon a moderately heated plate, and the other side is varnished in like manner. After three coats have been laid upon each side the paper is dried. It can be cut without danger and made into cartridges.—*Chron. Indust.*, Jan. 1, 1883; *Jour. Frank. Inst.*, [3] **86**, 468, Dec. 83.

This recalls the "Explosive Paper" described as follows in *Boston Journal Chemistry*, **9**, 112, Apr., 1875. Make a mixture of saltpetre 8 parts; chlorate of potash, 5 parts; charcoal powder or pulverized coal, 1 part; fine sawdust of hard wood, 1 part; and a little mucilage, gum or other binding material; put water enough on it to change it into a pasty mass, work it well through, and soak strips of heavy blotting paper in it. If you dry these strips you obtain explosive paper; if you roll them up tightly when wet and let them dry, you obtain little blocks which, when confined and fired, will explode with great violence, but will not easily go off by percussion or friction alone.

Mr. C. John Hexamer continues† his discussion of the means for the "Prevention of Dust Explosions and Fires in Malt Mills" in the *Jour. Frank. Inst.*, **116**, 200, Sept., 1883, and describes several devices which he has invented for this purpose.

The *Bulletin of the Edison Electric Light Company*, *No.* 22, April 9, 1884, announces the installation of a 100-light machine in the government powder mill at Spandau, Prussia.

*Proc. Nav. Inst. **8**, 449. *Proc. Nav. Inst. **9**, 295.

At a factory in Neusalz a large cast-iron wash-kettle was used to hold water, into which melted iron was allowed to flow, in a moderate stream, for making iron shot. On October 23, 1882, one of the workmen, by mistake, allowed the iron to flow too rapidly. There was a sudden development of steam, which threw out a part of the water, frightening the laborer and causing him to drop his ladle, so that about 20 kilogrammes (44 pounds) of melted iron fell at once into the water. There was an immediate rapid outburst of steam and a loud explosion, which shattered the kettle into fragments, tore up the wood-work, threw the workman nearly eight feet backwards and broke his right leg. Only a very small piece of the kettle was found where it stood; some of the pieces were thrown to a distance of about fifty feet.—*Jour. Frank. Inst.*, **116**, 237, Sept. 1883; *Dingler's Poly. Jour.*, March 7, 1883.

Table showing the percentage of Nitro-glycerine contained in the different grades of Atlas Powder, and the distinguishing marks of corresponding grades of "Hercules," "Giant," "Etna," "Hecla," and "Judson" Powders.*

Atlas. (Standard.)		Hercules.		Giant.		Ætna.		Hecla.		Judson.	
Brand.	Per Cent. N. G.	Brand.	Per Cent. N. G.	Brand.	Per Cent. N. G.	Brand.	Per Cent. N. G.	Brand.	Per Cent. N. G.	Brand.	Per Cent. N. G.
......	...	....	...	....	...	....	...	....	...	R.R.P.	5 and under.
.....	...	....	...	....	...	....	...	....	...	F.	10
F+	15	....	...	....	...	No. 5.	15	....	...	FF.	15
E.	20	No. 4.	20	M.	20	....	...	No. 3.	20	F.F.F.	20
E+	25	No. 4 S.	25	....	...	No. 4 X.	25	No. 3 X.	25	......	...
......	...	....	...	XXX.	27	....	...	....	...	......	...
D.	30	No. 3.	30	....	...	....	...	No. 2.	30	.....	...
......	...	....	...	No. 2 C.	33	....	...	....	...	......	...
D+	35	No. 3 S.	35	....	...	No. 3 X.	35	No. 2 X.	35	......	...
C.	40	No. 2.	40	No. 2.	40	No. 2.	40	No. 1.	40	......	...
C+	45	No. 2 S.	45	No. 2 Extra.	45	....	...	....	...	......	...
B.	50	No. 2 SS.	50	New No. 1.	50	No. 2 XX.	50	No. 1 X.	50	......	...
B+	60	No. 2 SSS.	55	....	...	....	...	....	...	......	...
......	...	No. 1.	65	....	..	No. 1.	65	....	...	......	...
A.	75	No. 1 XX.	75	No. 1.	75	....	...	No. 1 XX.	75	......	...

* "*Atlas Powder,*" *a Nitro-glycerine Compound*, p. 25, published by Repauno Chemical Co Philadelphia, Pa.

by a dotted line, from which it may be seen that from her upright position to that of an inclination of about 50 degrees she differs but little from the Daphne, and that beyond 50 degrees her leverage becomes negative until inclined to 90 degrees, when a righting effort reappears.

In examining the curve of the H. F. Dimock two maxima appear: the first at an inclination of about 35 degrees, or at nearly the same inclination at which the righting efforts of the Daphne and Hammonia are greatest; and beyond 35 degrees and to an inclination slightly beyond 45 degrees the righting effort slowly diminishes, but after passing this inclination it increases again until at about 70 degrees a second maximum appears; from this and to 90 degrees her leverage slowly diminishes, but remains positive throughout.

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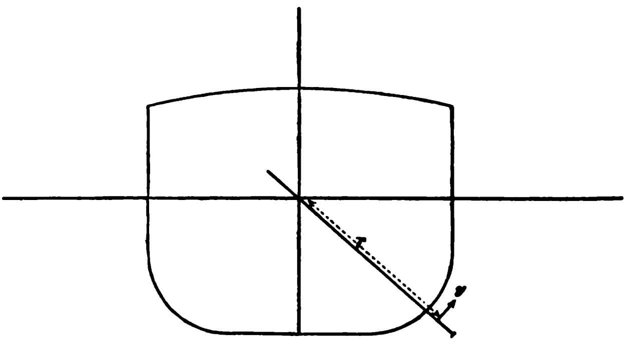
NOTES ON BILGE KEELS.

By Assistant Naval Constructor Francis T. Bowles, U. S. N.

Theory.

The following is an approximate solution for the amount of resistance opposed by a bilge keel to isochronous rolling of a ship in still water.



Let $A =$ area of the keel in square feet.

$r =$ the mean distance of the middle of the depth from the axis of oscillation.

The resistance varies as the square of the velocity in feet per second, and $\therefore = cv^2$ in lbs. per square foot, the constant c being taken as 1.6, somewhat larger than the constant usually given for the normal pressure on inclined planes, though it has been specially determined and is probably nearly correct.

Let $\theta =$ angle of inclination of the ship at time t.

$\theta =$ extreme angle of inclination,

then $\frac{d\theta}{dt} =$ angular velocity of the keel, and $\frac{rd\theta}{dt} =$ its linear velocity,

so that $cAr^2 \left.\frac{d\theta}{dt}\right]^2 =$ resistance at time t, and supposing the plane of the keel to pass through the axis of oscillation, then

$$cAr^3 \left.\frac{d\theta}{dt}\right]^2 = \text{moment of the resistance about this axis,}$$

$\therefore$ the work done in one roll $= \int_0^{\theta_n} cAr^3 \left.\frac{d\theta}{dt}\right]^2 d\theta$. For isochronous rolling, $\theta = \theta \sin \frac{\pi t}{T}$, where $T =$ period of one complete roll from side to side * $= \frac{2}{3}\frac{\pi^2}{T^2} cAr^3\theta_n^3$. Similarly, the work done in the roll from the upright to $\theta_{n+1} = \frac{2}{3}\frac{\pi^2}{T^2} cAr^3\theta_{n+1}^3$, $\therefore$ the total work done in a single swing $= \frac{2}{3} K(\theta_n^3 + \theta_{n+1}^3) =$ approx $\frac{4}{3} K\theta^3 = \frac{4\pi^2 cAr^3\theta^3}{3T^2}$.

Now the energy expended in a single swing $=$ approx. $Wm\theta\Delta\theta$,

$$\therefore\ CWm\theta\Delta\theta = \frac{4\pi^2 cAr^3\theta^3}{3T^2},$$

where $W =$ weight of the ship in lbs.
$m =$ metacentric height.
$\theta =$ maximum angle of inclination.
$\Delta\theta =$ rate of extinction or decrement of the inclination in one single swing.
$c =$ constant expressing the ratio of the total energy expended in a single swing to the work done by the bilge keels.

$$\therefore\ \Delta\theta = \frac{4\pi^2 cAr^3\theta^2}{3T^2 Wmc}.$$

---

* *Note.*—$U_n =$ work done in rolling from θ_n to the upright

$$= \int_0^{\theta_n} K' \left.\frac{d\theta}{dt}\right]^2 d\theta\text{, now } \theta = \theta_n \sin\frac{\pi t}{T}\text{, Let } a = \frac{\pi}{T},$$

$$\left.\frac{d\theta}{dt}\right]^2 = a^2\theta_n^2(1 - \sin^2 at) = a^2(\theta_n^2 - \theta^2)$$

$$\therefore\ U_n = K'a^2\int_0^{\theta_n}(\theta_n^2 - \theta^2)\,d\theta = K'a^2\left(\theta_n^2\theta - \frac{\theta^3}{3}\right)\Big]_0^{\theta_n} = \tfrac{2}{3}K'a^2\theta_n^3.$$

Similarly the work done in rolling from o to $\theta_{n+1} = \frac{2}{3}K'a^2\theta_{n+1}^3$, and $\therefore$ the work done in a single swing $= \frac{2}{3}K'a^2(\theta_n^3 + \theta_{n+1}^3)$.

$$\text{Now } (\theta_n^3 + \theta_{n+1}^3) = \left\{\frac{(\theta_n + \theta_{n+1})^2}{4} + \frac{3(\theta_n - \theta_{n+1})^2}{4}\right\}(\theta_n + \theta_{n+1})$$

$$= 2\left(\frac{\theta_n + \theta_{n+1}}{2}\right)^3 \text{approx.} = 2\theta^3.$$

Taking similar ships of different dimensions and comparing the rates of extinction we have

A varies as	1^2	where $1 =$ the linear dimension.	
r^2	"	"	1^2
T^2	"	"	1
W	"	"	1^3
m	"	"	1

therefore $\Delta\theta =$ constant — or the rate of extinction due to bilge keels is independent of the size of the ship, and they are therefore equally efficient for large and small ships. As a matter of fact, however, bilge keels are more effective on small vessels than on extremely large ones, because of the practical difficulties of fitting large vessels with keels of depth in proportion to their other dimensions; for example, if a vessel 150 feet long has keels 12″ deep, a similar ship 450 feet long should have them 36″ deep, in order to be equally effective, but the difficulties in docking interfere with the use of such deep keels.

Comparing ships of different types, the extinctive effect increases:

(1). As the area of keel increases.

(2). As the period of the ship decreases.

(3). With the increase of the amplitude of roll.

Now, if m is increased T is decreased, and, if we vary the type of ship, the bilge keels are most valuable in ships having great metacentric heights and small moments of inertia, or in shallow broad vessels with concentrated weights amidships, as in the monitors or the small English gunboats; on the contrary, in the Inflexible, with armor and coal at the sides, the bilge keels are not so efficient.

The idea has been advanced that, in order to prevent pitching and scending, the main keel at the ends should be broadened into a horizontal palm. Examining our formula for $\Delta\theta$, we see that this surface A will be comparatively small; while period of pitching is rather smaller than for rolling; the metacentric height is large and the amplitude very small; and hence there is reason to believe that the desired effect cannot be realized.

The following example is partly hypothetical. The actual measurements are taken from the Chicago, and the remaining data are roughly estimated by comparison to represent the qualities of that ship as designed.

Total work done in a single swing $= \dfrac{4\pi^2 cAr^3\theta^3}{3T^2}$.

For a vessel of 4500 tons displacement, suppose

A = area of two keels = 440 sq. feet.

r = mean distance of the centre of their depth from a fore and aft axis through centre of gravity of the vessel = 22.08 feet.

θ = max. angle of roll = 15°.

τ = period of single swing = 6.5 seconds.

c = 1.6.*

then, by substitution in the above formula, we find that the total work done in a single swing, namely from one side to the other,

= 42,355 foot lbs. at 15° max. angle of roll.
12,549 " " " 10° " " " "
1,568 " " " 5° " " " "

Now we have, from Moseley's formula for dynamical stability, that $Wm\theta\Delta\theta$ = energy expended in producing a single swing of the ship in which

W = weight of the ship in pounds = 4500 × 2240.

m = distance of the centre of gravity below the metacentre = 3 feet.

$\Delta\theta$ = decrement of the angle of oscillation in a single swing.

Assuming $\Delta\theta = .03\theta + .005\theta^2$

we find $\Delta\theta = 1.575°$ at $\theta = 15°$
0.8° " " = 10°
.275° " " = 5°

and the total energy expended in a single swing from an initial heel of

15° is 217,710 ft. lbs.
10° " 76,663 " "
5° " 12,634 " "

and therefore C or the ratio of the work done by the bilge keels to the energy exerted in a single swing

= .1945 at 15°
.1702 " 10°
.124 " 5°

Thus we see that at an initial angle of heel of 15°, the bilge keels do about 20 per cent. of the work done in resisting rolling. It should be remembered in connection with this that Mr. Froude showed that about 75 per cent. of the work done in rolling was exerted in forming waves. The amount of this resistance is, of course, mainly dependent on the form of the ship.

* Naval Science, vol. III, p. 320.

The following quotations give the most valuable and conclusive testimony as to the value of bilge keels:

Effect on English Troop Ships, 1871. *Committee on Design*, App. p. 330. "Serapis. Since fitting the bilge keels the maximum roll in a heavy Atlantic beam sea was reduced to 23° leeward, 14° windward, a reduction of 10° each way. Other captains reported that the speed was not influenced, and that the bilge keels acted beneficially."

These keels were 27 inches deep.

Admiral Ryder, p. 286, vol. 13, *Inst. Nav. Architects*. After alluding to the favorable effect of bilge keels on the troop ships he says: "In the report which was sent to the Admiralty as to the effect on the turning power of the ship after the bilge keels had been put on, it was said that not the slightest difference could be detected; and as to the effect upon the speed, a measured mile had been run, both before and afterwards, and not the slightest loss could be detected in that respect either." *

Mr. Wm. Froude, vol. 15, p. 67, *Inst. Nav. Architects*. "The Greyhound, fitted with bilge keels, was sent to Plymouth in order that I might, with the automatic apparatus which I had contrived for recording the rolling of ships, try some experiments with that ship as compared with another ship of the same size and form in the same seaway. I had an automatic apparatus in each ship for recording the rolling. The Greyhound was fitted with bilge keels 3 feet 6 inches wide, and 100 feet long, and the Perseus, another ship, was simply trimmed until she rolled in still water at the same natural period as the Greyhound, or as nearly so as possible. Probably, too, her natural properties of rolling were closely on a par with those which the Greyhound would have possessed if she had been divested of her bilge keels. Three times we had them outside the breakwater at Plymouth in a tolerably rough sea. We could not indeed find a long rolling sea that would make the ships roll regularly; but the upshot was that upon all occasions the Greyhound rolled just half as much as the Perseus rolled. The biggest roll we got out of the Perseus was about 23°, and the biggest roll we got out of the Greyhound was 11½°, and the periods were just the same. The addition of bilge keels does not materially augment the period, but it augments

* Cases are recorded where appreciable loss of speed has resulted from the use of bilge keels, but it has usually been found to be due to the faulty method of fitting, that is, fault either in position, direction or form.

immensely the destructive power of the surrounding water in killing the oscillation that the wave originates. The irregularity of the sea rendered the diagrams somewhat difficult to analyse, and did not enable me to determine in detail, as closely as I could have wished, the forces which were in operation at each instant; still, the fact was that the Greyhound rolled only half what the Perseus did. The last day that I was out the sea was rougher than upon any former occasion, and just at the moment when we were turning homeward I happened to look over the ship's side, when there had been a deeper lurch than usual, I was startled by sight of a large breadth of timber floating. Presently I recognized it as one of the ship's bilge keels which had been torn from her side. Having been fixed on temporarily with slight bolts, as not originally intended for rolling experiments, but merely for towing experiments, the bilge keel proved unequal to the strain, and thus one came off in the lurch. The diagram from that period till the time we entered the harbor showed relatively a considerable increase of rolling. Thus with the two bilge keels at work the Greyhound rolled just one half what the Perseus rolled; when one of them had given way her superiority had greatly diminished.

We rolled the Greyhound in Portsmouth Harbor, and obtained what is called her rate of extinction, repeating the experiments both before and after the bilge keels were put on. The extinguishing power is the power which the water possesses of bringing the ship to rest after she has been set rolling. Before the bilge keels were fitted we rolled her by running men from side to side and worked her up to an angle of 7°; but after they were fitted we could no longer do this, but we pulled her over with a heavy purchase until she attained the 7° of inclination. In each case she was allowed to continue her oscillations freely until she came to rest. The gradual extinction of the oscillations was automatically recorded. The Perseus was afterwards similarly treated at Devonport. Comparing the rate of extinction of the Greyhound without her bilge keels with that of extinction of the Perseus as thus tested, we found the Greyhound had a more persistent roll than the Perseus had. When she was started with a roll of 7° she made many more rolls before she came to rest than the Perseus did when rolled at the same angle. That was carefully ascertained by the automatic apparatus. The Greyhound, which was the worse ship of the two, without the bilge keels rolled only half as much as the Perseus would have rolled with them."

In his evidence before the Committee on Designs of Ships of War (1871), Mr. Froude gave the following table of results of many observations upon the rolling in still water of a large model of the Devastation. The model was 1/32 the dimension of the ship, and loaded to give the corresponding displacement, centre of gravity and distribution of weight, as in the ship itself.

Conditions.	No. of double rolls with 8½° initial angle.	Period of double roll.	No. of double rolls with 24½° initial angle.	Period of double roll.
(1) No bilge piece	31½	1.77″	29	1.78″
(2) Single 21 in. bilge piece on each side,	12½	1.90	8½	1.90
(3) Single 3 ft. " " " "	8	1.90	6¾	1.90
(4) Pair of 3 ft. " pieces " "	5¾	1.95 1.90	5½	2.00 1.85
(5) Single 6 ft. " piece " " .	4	2.00 1.98	3½	2.00 1.75

At 8½° initial angle the edge of the freeboard was brought to the water level.

At 24½° the top edge of the breastwork came to the water level.

The model was also tried in a seaway with corresponding variations in bilge piece conditions. When the trial was made the waves were, relatively to the model, steeper and more violent, as well as longer in period, than any which in any sea whatever the ship herself could have to encounter. Their height from hollow to crest was from 15″ to 18″ with an exceptional ridge of about 2 feet, heights which when measured on a scale of the model are equivalent to waves of from 45 to 54 feet, and occasionally over 70, if encountered by the ship herself. Their period from crest to crest being 2″.1 to 2″.25, the metacentric period of the model being 1″.7 or 1″.8, while her period was probably 2″.1 to 2″.2 for rolls of large range, so that it was a most trying sea to her.

Condition of Model.	Maximum deviation from vertical.
1. Single 6 feet bilge piece each side	3¼° to 5°
2. Single 3 " " "	8° " 3½°
3. Without bilge pieces "	20° and 21° and upset.

MM. Duhil de Benazé and Risbec's experiments on the Elorn, a vessel of fine form, which itself exerted great resistance to rolling,

are by no means so remarkable as those of Mr. Froude's, just quoted, except in the case where the bilge pieces were placed at the water line. These experiments showed the reduction of amplitude to be very rapid, owing to the impact at the surface of the water. Though this materially increases the extinctive effect of the keels, the shock and the tremors produced in the vessel are unpleasant, and in the case of the overhanging armor-shelf in the early monitors injured the hull.

Little definite information is to be found as to the resistance opposed by bilge keels to the propulsion of ships. Available testimony is almost unanimous that, where they are properly applied, there has been no perceptible loss of speed. Properly interpreted, this confirms what might be reasonably expected. A loss of speed is only perceptible under ordinary circumstances from the maximum or the regular steaming speed; the observation being made on the former in a war ship and the latter on an ocean steamer. At these speeds, the proportion of the total resistance due to surface friction is much reduced, from 60 to 70 per cent. to 35 to 50 per cent. Assuming that the resistance of the bilge pieces consists wholly of surface friction, and neglecting the fact they are in the frictional wake, the area of their surfaces seldom exceed 5° of the immersed surface, therefore their resistance will not exceed 2½ per cent. of the whole. Supposing the resistance to vary as the square of the speed, it is evident that the loss of speed due to the application of bilge keels would not be detected by ordinary means. At low speeds the expenditure of power would be palpably increased by bilge keels, and on this account an ocean "tramp" could not afford the luxury of steadiness at sea. Mr. Froude's experiment to determine the resistance of the bilge keels of the Greyhound * was contradictory and unsatisfactory, but is, notwithstanding, quoted to show their small resistance.

Bilge keels are usually applied throughout one-half to two-fifths of the ship's length amidships, and in fitting them the following general considerations should be attended to, but, of course, their fulfilment is restricted by other circumstances.

I. They should be placed so as to oppose the maximum resistance to rolling. The keels will obtain the greatest linear velocity if placed at the greatest distance from the axis of transverse oscillation, namely near the turn of the bilge; and in order to act normally to the direc-

* Vol. 15, Inst. Nav. Architects.

. of their motion should be in a plane passing through this axis; · probable, however, owing to the stream line motions and frictional ⁚e, that this object is efficiently secured by placing the keels normal ·he midship section.

II. They should be placed so as to oppose the least resistance to ·opulsion. The best method of fulfilling this requirement can only ·· determined by experiment, but the best practice, which is presum-ly the result of not only experience, but of special trial, requires hat the intersection of the plane of the bilge keel with the middle vertical longitudinal plane of the ship shall be a line parallel to the ıoad-water plane. Or, in the terms of the mould loft, it should be a diagonal plane, provided the ship is laid down at her normal trim.

It may be noticed that the sketch of a keel No. , as applied to a wooden vessel, shows that the bilge keel is fastened to the surface of the ship along the line in which a vertical longitudinal plane would intersect it, but that instead of being in this plane, in which case it would analytically fulfil the above condition, it is maintained normal to the cross section, thus forming a twisted surface, which, *prima facie*, would cause a greater resistance to propulsion than a plane surface.

III. They should be of sufficient strength to withstand the normal pressure of the water in rolling.

IV. The fastenings and parts should be so arranged that the keels should partly or wholly come off without permanent injury to the hull in case of taking the ground. In wooden or composite vessels this is provided for by an outer depth, or false keel, spiked on. In iron or steel ships all fastenings to the skin should be tap rivets nutted on the inside, so that if the keel is broken or twisted off the rivets will give way at the outside and leave the rivet holes plugged.

V. They should be placed so as to remain submerged at the usual angles of heavy rolling. There is no danger to the ship in emergence of the keels, and in fact the impact at the surface of the water renders them much more efficient in extinguishing oscillations. But it is better to keep them submerged on account of the danger to boats alongside.

The following sketches show the different methods of fitting bilge keels to ships constructed of various materials and on different systems. Figured dimensions show the scantlings of each, and in several cases the fastenings are described in detail.

PLATE 1.—STEEL SHIPS CASED WITH WOOD AND COPPER.

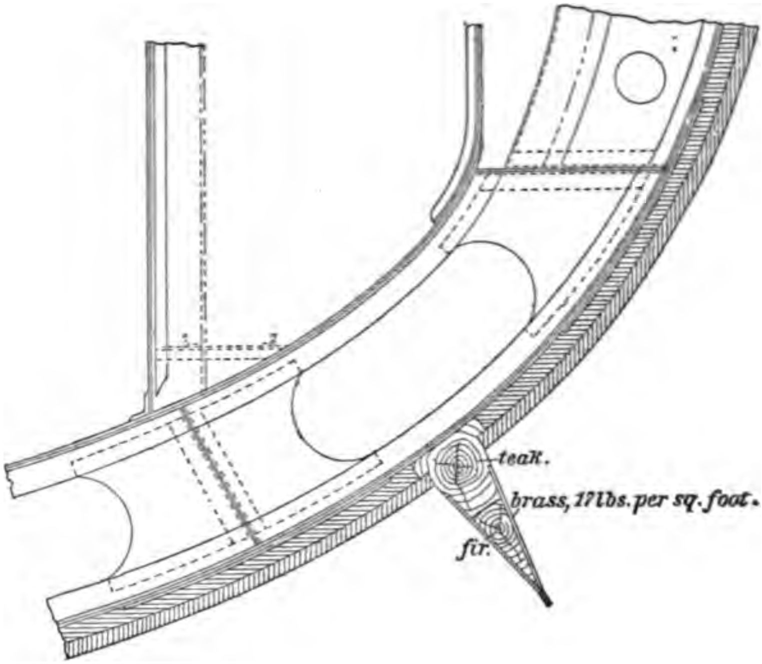
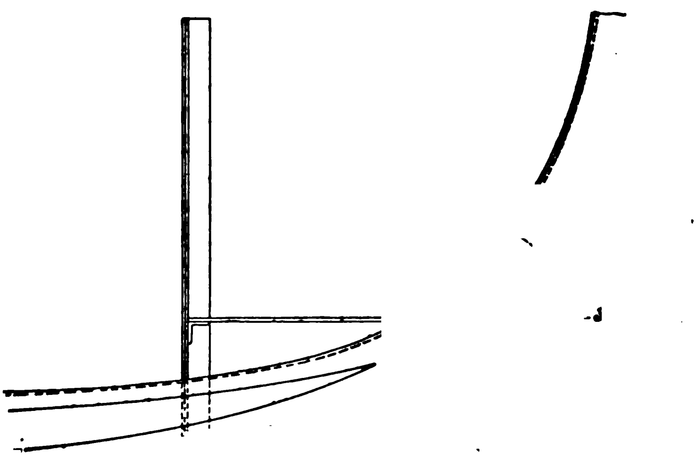
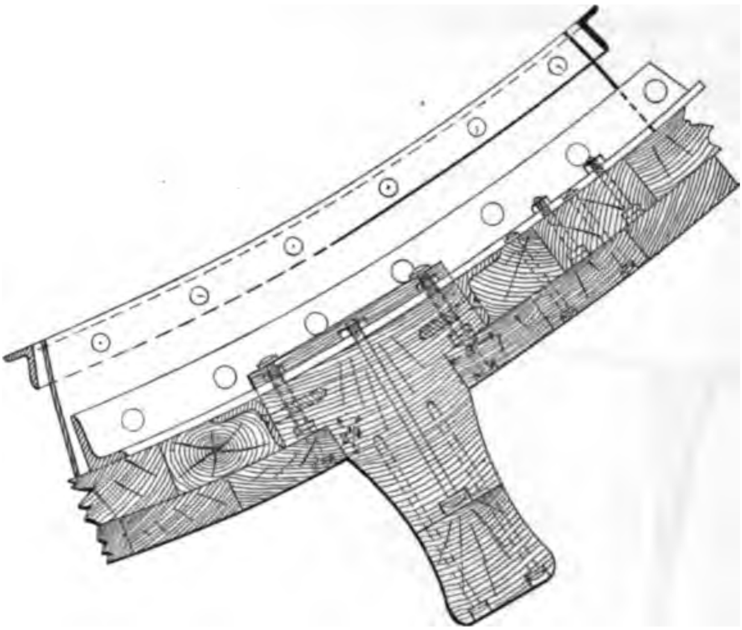


PLATE 2.—COMPOSITE VESSEL



The inner pieces are scored over the frames to a depth of 1½" and are secured to them by brass screw-bolts, ¾" in diameter, tapped into the frames and having nuts on the inside for double security. They are also fastened to the angle bars at the edges by galvanized iron screw bolts, about four inches long and ⅝" diameter. The inner pieces are also secured by copper through bolts ⅝" diameter to every alternate frame. The outer pieces are spiked to the inner ones.

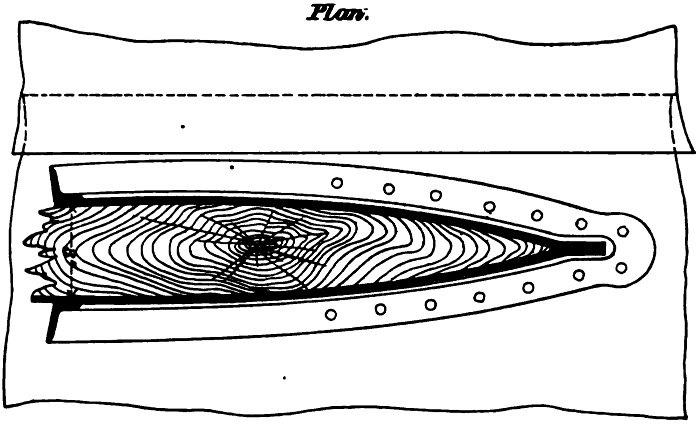
PLATE 3.—COMPOSITE VESSEL.



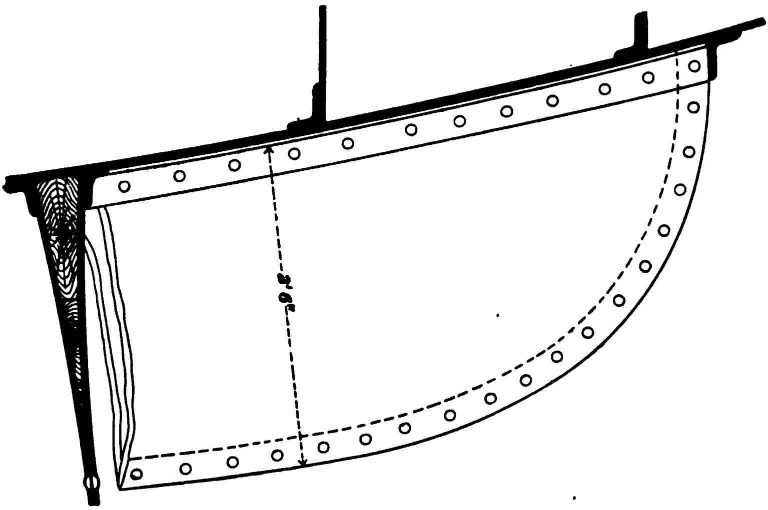
This keel (Plate 4), which is made in the shape of the letter V, is formed of 2½" plates filled in with yellow pine. The plates are brought together at the outer edge with just sufficient lap to take one row of ¾" rivets, spaced six diameters apart. The edges of the plates are fastened to the bottom plating by two angle irons 3½" x 3½" x ½". The rivets securing these angle irons to the bilge plates are ¾" and are spaced 7 diameters, the angle irons are secured to the bottom-plating by means of ¾" tap rivets, spaced 7 diameters. These tap-rivets are nutted on the inside when they pass through only the outside plating, but when through a frame as well they are merely tapped through.

PLATE 4.—IRONCLAD.

Plan.



Elevation.

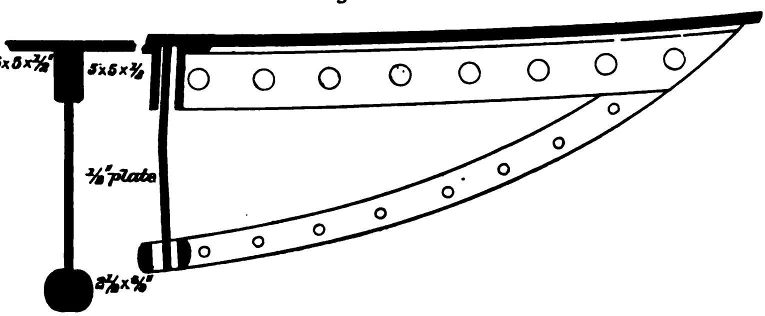


The plates composing the bilge keel are about 16 feet long and are butt-strapped on the inside with straps wide enough to take a single row of rivets on each side of the butt. The rivets are ¾" spaced 6 diameters.

The holes in the keel for the lines to collision mats are 2" diameter in pairs about 20 feet apart. These holes are lined right through the keel, and a ring of half-round iron is fitted round them on on each side to keep the rope from chafing.

This keel (Plate 5) is composed of a half-inch plate and two angle irons. The greatest width of the plate is 21″, tapering very gradually, and ending in a point as shown. It is fastened to the bottom by two 5″ x 5″ x ½″ angle bars, one each side (as shown in the sketch) connected to the bottom plating with ⅞″ rivets and screw bolts, spaced about 6 or 6½ diameters apart. On the outer edges of the keel are fastened two pieces of half-round iron riveted through and through with five-eighths rivets spaced six diameters. The plates of which the keel is composed are connected by double butt-straps, double riveted. At intervals along the keel holes are cut in pairs as guides to the lines of the collision mats; the distance between the two holes which form one pair is 1 foot 7 inches, and from one pair to another 12 feet 1 inch.

PLATE 5.—IRONCLAD.



This construction is frequently employed on merchant ships.

PLATE 6.—COMPOSITE VESSEL.

Fig. 1.

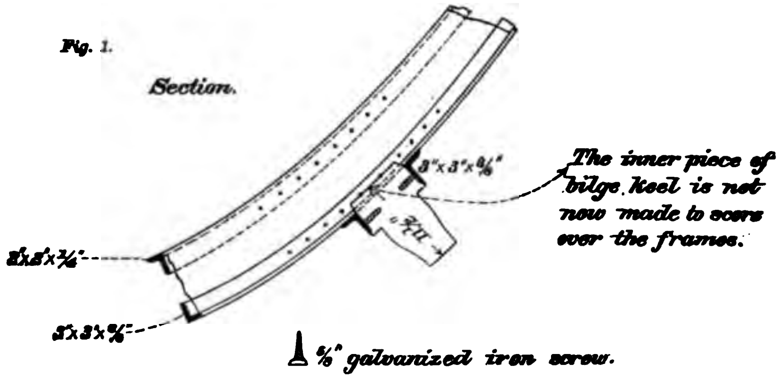


Fig. 2.

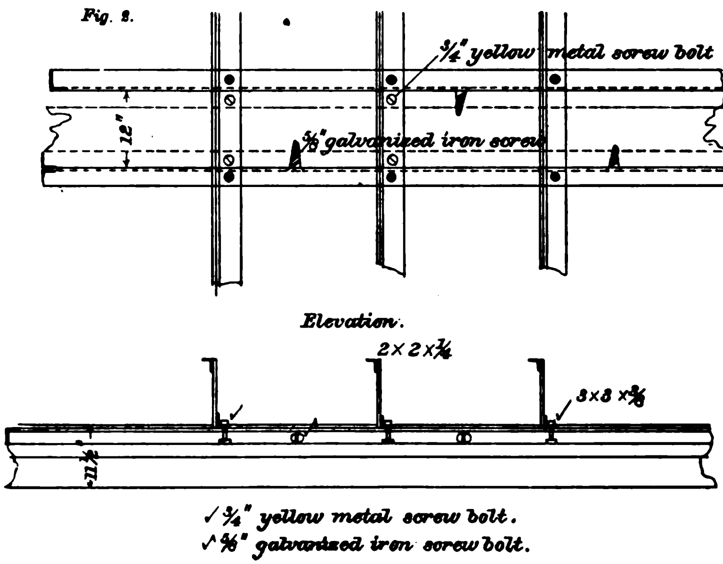
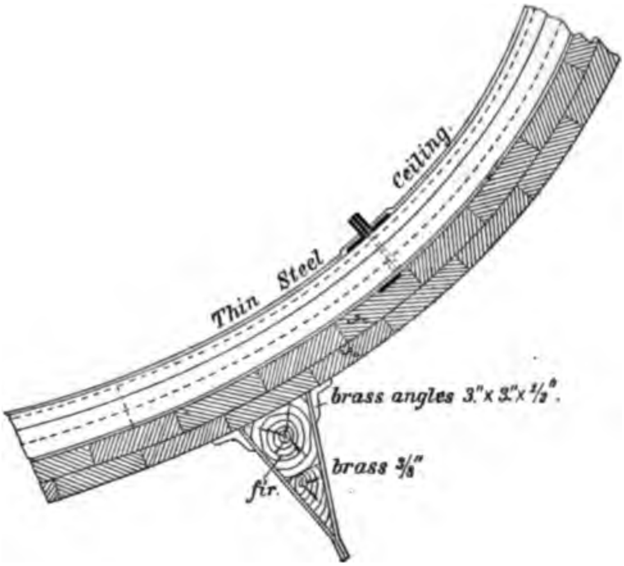


PLATE 7.—COMPOSITE VESSEL



Scale 1/2 inch = 1 foot.

phere contained 65 per cent. of moisture. Column 6, the gain or loss of the rate in saturated atmosphere, over the rate in an atmosphere containing 65 per cent. of moisture, or the rate during first forty-eight hours, minus rate during second forty-eight hours. Column 7, the daily rate when chronometers were surrounded by dry air. Column 8, the gain or loss of rate in dry air over rate in air containing 65 per cent. of moisture, or the rate during last forty-eight hours, minus rate during second forty-eight hours. Column 9 gives the extreme variation for the whole trial.

An inspection of the table shows that in 86 per cent. of the trials the chronometers lost while running in the damp air on their rates in semi-saturated air; this loss amounting in the case of one chronometer to more than three seconds daily. In dry air the gain in rate over the rate in air semi-saturated occurred in a little over 50 per cent. of the trials. But when 725 and 1262 had been oiled, the rate in dry was a gain upon the rate in semi-saturated air in 74 per cent. of the subsequent trials.

These trials seem to indicate that the rate of a chronometer varies with the hygrometric condition of the atmosphere, the chronometer running faster as the percentage of moisture decreases, and *vice versa.*

These experiments are to be resumed with a larger number of chronometers, and under conditions where the quantity of moisture can be measured.

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ON THE TENSION OF WINDING WIRE-GUNS.

BY PHILIP R. ALGER, ENSIGN, U. S. N.

The theories which have been advanced and generally accepted, relative to the elastic resistance of hollow cylinders, are based on the assumption that the cylinder will be deformed only when one of the tensions or pressures acting on it equals the resistance of the metal at the elastic limit under traction or free compression.

According to the theory of Clavarino, however, the cylinder must be considered as having reached its limit of elasticity when, from the effects of all the forces acting upon any one of its fibres, it undergoes an elongation or a contraction equal to that which takes place at the elastic limit in the mechanical tests respectively of traction or compression.

To make this difference more clear, consider an elastic right prism submitted to the action of three forces, X, Y, and Z, at right angles to each other. Let θ be the elastic limit and λ the elongation at the elastic limit of the prism under simple traction, and let i_1, ε_1, ε_1, be the changes of length in the three directions due to the force X, i_2, ε_2, ε_2 those due to Y, and i_3, ε_3, ε_3 those due to Z. Now the theory of Virgile asserts that the prism will take a permanent set in the direction of X only when X equals θ, regardless of the values of Y and Z, while the theory of Clavarino is that the prism will take a permanent set in the direction of X when $i_1 + \varepsilon_2 + \varepsilon_3$ equals λ, regardless of the value of X.

The tension at which wire must be wound in order that under a given internal pressure each layer may be at the same *tension* has been investigated in a previous paper; it is now proposed to determine the tension of winding such that under the strain of firing each layer of wire may have the same ***extension***.

Let $R_0 =$ inner radius of tube.
$R_1 =$ outer radius of tube.
$R_2 =$ outer radius of wire.
$P_0 =$ maximum internal pressure.
$T =$ limit of tension of wire under strain.
$T_0 =$ limit of tension of tube under strain.
$C_0 =$ limit of compression of tube (gun at rest).
$E_0 =$ modulus of elasticity of tube.
$E_1 =$ modulus of elasticity of wire.

Suppose the wire wound upon the tube in the proper manner, and the structure in equilibrium under the internal pressure P_0, each layer of wire having the same *extension* $\left(\frac{T}{E_1}\right)$. At a point of radius r in the mass of wire the existing extension $\left(\frac{T}{E_1}\right)$ is due to three strains, that of winding, that caused by the internal pressure, and that caused by the pressure of the outer layers of wire. Now, if we find the change of extension at r caused by the removal of the outer layers of wire and the disappearance of the internal pressure, and apply it to the extension which exists under these forces, the result will evidently be the extension which must be given to the wire in winding, and this multiplied by E is the desired tension of winding.

In a previous paper it has been shown that the change of tension (t_1') at radius r due to a variation (p_0) of the internal pressure and a variation (p_2) of the external pressure is given by the equation

$$t_1' = \frac{6p_0 R_0^2 R_1^2 - p_2(Ar^2 + B)}{Ar^2 - B},$$

where

$$\begin{cases} A = 2aR_0^2 + bR_1^2 \\ B = cR_0^2 + aR_1^2 \\ a = 1 - \dfrac{E_0}{E_1} \\ b = 1 + 2\dfrac{E_0}{E_1} \\ c = 2 + \dfrac{E_0}{E_1}. \end{cases}$$

Hence the change of *extension* at r is as follows:

$$(1)\quad d\left(\frac{\Delta r}{r}\right) = \frac{1}{E_1}\left(t_1' + \frac{p_2}{3}\right) = \frac{1}{E_1} \cdot \frac{18p_0 R_0^2 R_1^2 - 2p_2(Ar^2 + 2B)}{3(Ar^2 - B)}$$

where $p_0 = -P_0$ and p_2 remains to be determined.

Let p and t be the pressure and tension at radius r in the wire under the internal pressure P_0. Since, by supposition, the extension of each layer is $\frac{T}{E_1}$, we have,

$$\frac{1}{E_1}\left(t+\frac{p}{3}\right)=\frac{T}{E_1}, \tag{2}$$

$$t=T-\frac{p}{3}. \tag{3}$$

But we have also

$$rp=\int_{R_2}^{r} t\,dr. \tag{4}$$

Hence,

$$rp=\int_{R_2}^{r}\left(T-\frac{p}{3}\right)dr, \tag{5}$$

or, differentiating,

$$r\,dp+p\,dr=-\left(T-\frac{p}{3}\right)dr \tag{6}$$

$$\frac{dp}{\frac{2p}{3}+T}=-\frac{dr}{r}, \tag{7}$$

or, integrating and remembering that when $r=R_2$, $p=0$ and $t=T$,

$$p=\frac{3T}{2}\left[\left(\frac{R_2}{r}\right)^{\frac{2}{3}}-1\right]. \tag{8}$$

Now replacing p_2 in (1) by its value $-p$ given by (8), we have,

$$d\left(\frac{\Delta r}{r}\right)=\frac{1}{E_1}\cdot\frac{-6P_0R_0^2R_1^2+T\left[\left(\frac{R_2}{r}\right)^{\frac{2}{3}}-1\right](Ar^2+2B)}{Ar^2-B}. \tag{9}$$

But the extension to be given in winding has been shown to be $\frac{T}{E_1}+d\left(\frac{\Delta r}{r}\right)$, hence the tension of winding (t_r) must be

$$t_r=\frac{T\left(\frac{R_2}{r}\right)^{\frac{2}{3}}(Ar^2+2B)-3BT-6P_0R_0^2R_1^2}{Ar^2-B}. \tag{10}$$

In the case when the tube is of the same material as the wire, we have $E_0=E_1$ and (10) becomes

$$t_r=\frac{T\left(\frac{R_2}{r}\right)^{\frac{2}{3}}(r^2+2R_0^2)-R_0^2(3T+2P_0)}{r^2-R_0^2}. \tag{11}$$

Since the radial pressure, zero at the outside, increases as the inside of the mass of wire is approached, it is evident that the tension of winding to give uniform *extension* under internal pressure is the same at the outside and less at the inside than in the case where the wire is wound to give uniform *tension*.

To determine the value of P_0, the pressure which will strain the gun to its elastic limit, with T and T_0 given, we have, from (8), letting $r = R_1$,

$$P_1 = \frac{3T}{2}\left[\left(\frac{R_2}{R_1}\right)^{\frac{2}{3}} - 1\right], \tag{12}$$

and, from Claverino

$$P_0 = \frac{3T_0(R_1^2 - R_0^2) + 5P_1R_1^2}{4R_1^2 + R_0^2}. \tag{13}$$

The value of P_0 given by the above formula is generally about three-fourths of that given for the same structure by Virgile's formula.

One thing further remains to be determined, the compression of the bore due to the pressure of the wire when the gun is at rest. This, of course, depends entirely upon the radial pressure between the wire and the tube, which we will call P_1. Now we have already, from (8), the value of this pressure when the internal pressure is acting, and it is therefore only necessary to determine the change (p_1) in this value due to the disappearance of P_0. We have*

$$t_1' = t_1\frac{r^2 + R_1^2}{2r^2} - p_1\frac{r^2 - R_1^2}{2r^2}$$

$$t_1 = \frac{3p_0R_0^2(r^2 + R_1^2) - p_2r^2(cR_1^2 + aR_0^2 + 3R_0^2)}{Ar^2 - B}$$

$$t_1' = \frac{6p_0R_0^2R_1^2 - p_2(Ar^2 + B)}{Ar^2 - B}.$$

From these equations, letting $r = R_2$, $p_2 = 0$, and $p_0 = -P_0$, and eliminating t_1 and t_1', we have,

$$p_1 = -\frac{3P_0R_0^2(R_2^2 - R_1^2)}{AR_2^2 - B},$$

and this is the change of pressure at R_1 due to a change $(-P_0)$ of the internal pressure. But we have, from (8), that the pressure at R_1 while P_0 acts is $\frac{3T}{2}\left[\left(\frac{R_2}{R_1}\right)^{\frac{2}{3}} - 1\right]$,

hence
$$P_1 = \frac{3T}{2}\left[\left(\frac{R_2}{R_1}\right)^{\frac{2}{3}} - 1\right] - \frac{3P_0R_0^2(R_2^2 - R_1^2)}{AR_2^2 - B},$$

* Deduced in No. 27, Proceedings U. S. N. I., page 794.

and in order that the bore may not be compressed beyond the limit C_0, P_1 must not be greater than $\frac{3C_0}{5} \cdot \frac{R_1^2 - R_0^2}{R_1^2}$.

The actual compression of bore due to P_1 is $\frac{2P_1 R_1^2}{R_1^2 - R_0^2}$, but in order that the *linear* compression may not exceed $\frac{C_0}{E_0}$ it is necessary that P_1 should not exceed $\frac{3}{5} C_0 . \frac{R_1^2 - R_0^2}{R_1^2}$, and, as we are following Clavarino's theory, the latter is the assumption to be made.

PROFESSIONAL NOTES.

In examining the earlier reports of the Secretary of the Navy, many things of considerable historical interest in naval construction have been encountered. Notable among these are the communications of Lieut. W. W. Hunter, U. S. N., following the trial of the wooden steamer Union, in 1843, which was fitted, on his design, with horizontal paddle wheels, submerged at the after part of the ship. This vessel made a trial cruise from Washington to Boston and return; and while in Hampton Roads developed a speed of 10 knots an hour.

On the return from this cruise, Hunter addressed a letter to the Secretary of the Navy, A. K. Upshur (who was loud in his praise of this vessel), recommending the construction of vessels with similar means of propulsion, but built of iron. He set forth ably and with great lucidity the advantages of iron as a material of construction, and appends to his letter a recommendation for the use of an iron *shield deck* above the level of water-line amidships, and sloping to beneath it at the sides.

As this appears to be the earliest recorded proposal for the use of what is known as the protective, or submerged armor deck, now employed in almost every type of war vessel, and justly regarded as one of the most efficient methods of protecting both the machinery and the ship's buoyancy, it is here presented in full with the accompanying sketch. F. T. B.

WASHINGTON CITY, *November* 29, 1843.

Sir: I would respectfully request to append to my report of the 24th June, 1843, this notice of some of the advantages peculiar to sea steamers constructed on my plan, which have not heretofore been brought to the consideration of the Department.

1. Their peculiar model (which, while it gives the greatest capacity and buoyancy, carries with it the lightest draught of water, and thus renders all our Southern harbors available for the largest class of vessels of this construction) enables them to run boldly, without the apprehension of grounding, and, even in this event, they can receive no injury to their propellers.

2. From the driftwood in our Southern, and the ice in our Northern rivers and lakes, so destructive to the propellers of steamers, these propellers are entirely protected; being horizontal in their action, far below the surface, and throwing *from* them, by centrifugal force, a rapid current of water.

3. The horizontal action of the propellers, as just stated, and their separate and distinct action, renders the use of the rudder unnecessary to steer the vessel under steam, because she may be steered by the propellers, without the rudder, as has been often proven. She can thus turn on a *pivot*, or the *centre* of a circle, and may then give or avoid a raking fire at will; whilst all other vessels are dependent on their rudder to turn, and must then move on the *arc* of a circle. The loss, then, of the rudder in all other vessels destroys their ability to manœuvre, whilst these vessels are not exposed to the risk of injury in this most vulnerable point.

It is proper in this place to call your attention to an important part of my plan for war steamers (which has not as yet been embraced in the construction of any) which, by means of a shield deck, renders it impossible to sink them by means of an enemy's shot, notwithstanding every shot may pass through the sides of the vessel. This is so self-evident that it will admit of no doubt. The diagram and demonstration hereunto appended will explain it.

In conclusion, sir, it may not be out of place here to fix your attention to some of the facts connected with the development of this American improvement in the art of constructing, rigging, equipping, arming and propelling vessels, as shown in the steamer Union, the first experiment of any magnitude made with it.

In the construction of the Union, the chief effort was to develop the plan and furnish the government a strong, cheap and useful vessel. What degree of success attended the effort you can determine. Her frame is of heavy oak timber, sided fourteen inches, solid and caulked for eighty feet in her midship sections on the bottom and sides up to her berth-deck. She is planked to the water-line with heavy 6-inch oak plank, and ceiled with 4-inch oak and pine, and caulked to the berth-deck. Every plank may be torn from her sides and bottom and cause no leak to the vessel. She is copper-fastened more heavily than usual; is of 1040 tons, and cost, equipped and armed, ready for sea, by the official returns already presented to you, $113,909.94¼. The force that has hitherto been effected to propel her, at a consumption of twelve and one-half tons of bituminous coal in twenty-four hours, has been, in consequence of her defective boilers, one-third less than it will be when her new boilers, of 270 horse-power, are completed and in operation. This will still be a power far inferior to that employed for ocean steamers of the same tonnage. Official evidence has already been furnished you by disinterested persons that her rate of steaming with her first and defective boilers was ten miles per hour, whilst, as a sailing vessel, she was equal to any other. Thus, then, is established that for her tonnage and battery this first vessel cost far less than any war steamer hitherto constructed; and, from the success which has already attended her, with the experience gained in her construction, the assurance is given that a much higher rate of speed will yet be attained in the future construction of vessels upon the same plan.

DEMONSTRATION.

Let *AAA* be the water-line, and *BKB* be the shield-deck, of iron or faced with iron. The abutments of said shield-deck are joined and secured entirely around and within the vessel, at a given distance below the water-line, out of the reach of shot. The summit of said shield-deck is exactly amidships and so elevated that a greater space is contained between the shield-deck and the water-line above the water-line than between the shield-deck and water-line in the wings of the vessel below the water-line. The hatches are amidships, in the summit of the shield-deck, and are fitted to transverse fore and aft within the shield-deck at *CC*, with water-tight slides of iron. The abutments of the shield-deck at *BB* are, by reason of their distance below the water-line, out of the reach of shot; and the surface of the shield-deck being of iron, and forming, with the direction of any missive discharged against it from cannon afloat, an angle of over 135°; and as said angle will cause said missive to glance or be thrown off from said deck, it follows that that part of the vessel contained under the surface of said shield-deck is secure from the effect of shot. Now, compare the space contained between that part of the water-line, that part of the inner surface of the vessel's side, and that part of the surface of the shield-deck at *HH*, to that contained between the part of the water-line and part of the surface of the shield-deck at *KKK*, and it is evident that, should the side be so pierced or torn by shot as to fill the first-named space at *HH* with water (being all the water that can possibly be admitted), the buoyancy gained by the greater space at *KKK*, together with the displacement contained under the shield-deck and water-line, make it manifest that said vessel cannot be made to sink by the means named in the premises, and the engines and machinery, being far below the water-line, will be by said means protected. Very respectfully, your obedient servant,

(Signed) WM. M. HUNTER,
Lieut. U. S. Navy.

To Hon. David Henshaw,
Secretary of the Navy.

WIRE-WOUND GUNS.

In the present transition state of gun construction in this country, and in view of the attention the subject is now receiving with reference to providing a much needed armament, it is especially important that information which may influence public action should be authentic; and these circumstances call for the correction of erroneous statements and misconceptions which might otherwise be allowed to pass without comment.

The publication of the following papers has been determined by the considerations above mentioned.

Had my time permitted, I would have been glad to present the subject more fully and systematically. The fact that the papers were written to meet misconceptions actually occurring may render them not less useful for the purpose for which they are now issued. W. E. W.

[COPY.]

WASHINGTON, *November* 24, 1884.

LIEUTENANT W. H. JAQUES, U. S. N., *Secretary, &c.*

Sir: In the extended and valuable contribution you have lately made to the Proceedings of the United States Naval Institute (Vol. X, No. 4), I find on page 825 the statement that "the most practical application of the wire question" (meaning, doubtless, the most practical method of wire-gun construction) "appears in the designs for the 6 inch and 8-inch wire-wound B. L. rifles, prepared by the Bureau of Ordnance, Navy Department."

The unqualified form of the assertion might naturally lead one to suppose it to express something more than the individual opinion of its author, and possibly to give it more weight than it is entitled to.

Whatever may have been the good reasons which led to the presentation of the Bureau's designs, I think I cannot mistake in saying that the Chief of the Bureau does not agree with the statement quoted, and it would be unfortunate if the decision of the wire-gun question should be influenced by such an opinion.

It was with much hesitation on my part that license was given for the construction by the Bureau of a gun upon the design commended in the above extract, upon the ground that (whatever its value relative to hooped guns) its inferiority to wire-wound guns of other design, which it was likely to precede in completion and proof, would almost of necessity be prejudicial to the reputation of wire-gun construction in its best forms—a matter of no inconsiderable importance in connection with the prospective armament of the defences of the country.

For a statement of some of my objections to the design in question, reference is made to the accompanying letter to the Chief of the Bureau of Ordnance.

Referring to your remarks upon the wire-winding machine, I will state that only as an incident in the superintendence of the construction of an 8-inch wire-wound gun of my own design and patent, for the Bureau of Ordnance, was I employed to superintend the construction of a winding machine, and that *none* of the difficulties "have been overcome by" any "Inspector of Ordnance." The high character of the officers who have held the position mentioned assures me that they have not made such a claim. The nearest approach to anything of the kind of which I am aware is the employment of "vulcanized fibre" for the "initial friction strips," by Lieut. Arthur P. Nazro, during a part of the winding of the 6-inch gun, which I believe has worked at least as well as any other material tried.

In connection with this subject allow me to remind you that while it is honorable and of general utility, to bestow merited commendation upon those with whom one's association may be presumed to afford him some share in it, it is not less so to be strictly just in all cases.

Please be kind enough to bring this communication to the notice of the members of the Board of which you are secretary.

Respectfully, your obedient servant,

W. E. WOODBRIDGE.

[COPY.]

WASHINGTON, *November* 19, 1884.

COMMODORE SICARD,
Chief of the Bureau of Ordnance, U. S. N.

SIR: I am aware that to the extent your views are known, it is unnecessary to guard against the impression that the wire-winding system of gun construction is about to receive a decisive test in the fabrication and proof of the 6-inch wire-wound rifle now being made at the Washington Navy Yard. It is, however, so difficult to convey to the general public, or even to those whose province of action brings them into nearer connection with the subject, accurate information upon such questions, that the performance of the gun mentioned will almost unavoidably be regarded as representative of the capabilities of the wire-winding system.

To guard in some measure against the effects of such an error, I desire to put upon record a brief statement of what I conceive to be the relative defects of the mode of construction employed in the gun referred to, and I have the honor to request that it may be placed upon the files of your department.

Referring to the accompanying drawing taken from your late report, I would first call attention to the bands A and B, which are impaired in their functions in consequence of being, in the design under consideration, necessarily placed (shrunken on) before the winding of the gun. However well adjusted the shrinkage with which they may be applied, the bands, being resisted not only by the cylinder of metal lying immediately beneath them, but also by the continuous adjacent metal, will be unable to compress the jacket and interior tube at the places where they are applied to an extent more than a small fraction of their capabilities of resistance within their elastic limit. After the winding of the wire, which should be conducted with tensions that will, in the aggregate, compress the jacket and tube so far as to bring every portion of the metal within the coil to the full measure of compression of which it is capable up to its elastic limit, the bands will, under the most favorable supposition, be relieved of much the larger portion of their tension, and consequently will afford small support to the portions of the gun to which they are applied.

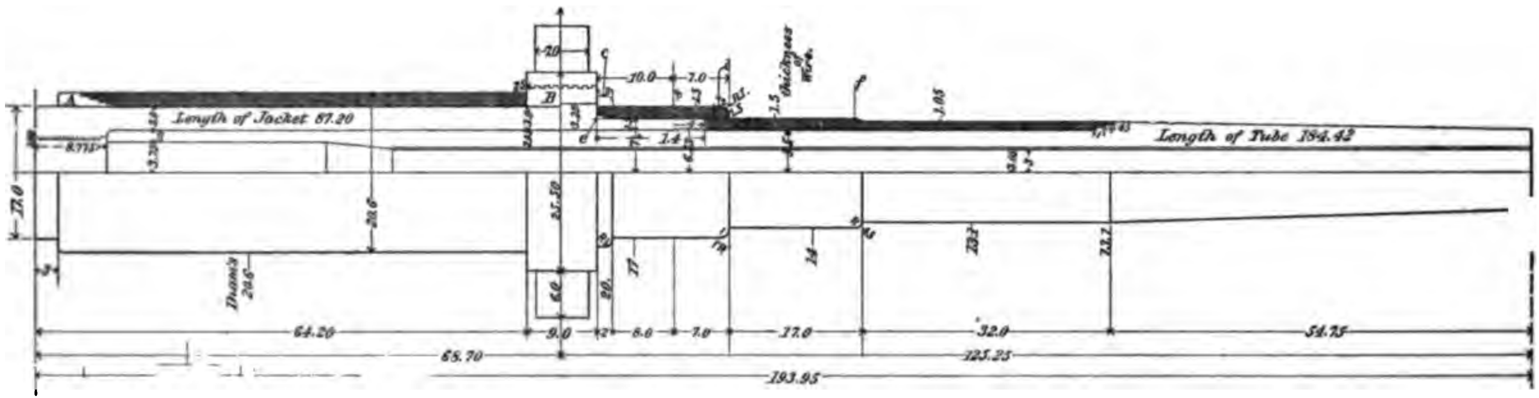
This result will be less important in the case of the band A than in that of the band B. In the former instance the support of the breech-screw will be somewhat diminished, and the tangential resistance of the rear portion of the chamber will be in some measure impaired.

The band B, carrying the trunnions, covers that portion of the tube and jacket which corresponds to the position of the rear of the projectile when the powder gases have made an expansion of only about 50 per cent., at which point the pressures, with the powders now in use, are not much below their maximum. This would, then, be a particularly weak point in the construction.

It may be proper to state, however, that the design considered admits of a modification, which will be found suggested in drawings heretofore presented by the writer, permitting the wire-winding to be done before the application of the bands, which may then be applied under the full tension of shrinkage.

The gun so modified would, doubtless, stand fairly in advance of hooped steel guns of similar dimensions.

SIX-INCH WIRE-WOUND B.L. RIFLE, BUREAU DESIGN.



Continuous winding from the breech to a point forward of the trunnions, as indicated in designs brought to the attention of the Bureau,* would better sustain the high pressures now extending far forward as a consequence of the use of the present large charges of powder.

The introduction of a "jacket" of low tensile elastic limit in the design under consideration, in place of longitudinal staves of high elastic limit, such as presented in the 8-inch wire-wound gun now commenced by the Bureau upon the plan furnished by myself, is considered another source of inferiority. Without stating all the details in which the jacket is held to be inferior, mention will be made of the most important particulars.

In the jacketed gun all the longitudinal stress is brought upon the jacket. In the gun in which staves are used the tube has a not unimportant share in sustaining the longitudinal strain. But omitting further reference to the assistance of the tube, we find in the cold-wrought steel, from which the staves are made, a resistance for a given cross-section more than double that of the material employed in the jacket, and therefore less than half the area of metal in the staves (that is to say, less than half the weight of the jacket) is sufficient to sustain the same longitudinal stress.

The difference in the relative elastic limits of compression is not less important in its results. Proper construction in a wire-wound gun requires that the tension of the wire should never revert to compression. To secure this result there must be within the coil of wire a resistance to compression equal (when free from internal pressure) to the aggregate tension of the wound wire. In one case this compression is brought upon the tube and jacket, and in the other upon the tube and staves. The staves present the same superiority in respect of elastic resistance to compression that they offer in relation to extension, and in the function just mentioned, as well as in that before considered, less than one-half the metal suffices to replace the resistance of the jacket.

The reduction of diameter at the inner surface of the coil of wound wire, obtained by employing cold-wrought staves rather than the jacket, effects the same reduction of exterior dimensions, and, of course, effects an economy of material considerably greater than the saving on the jacket alone.

Not only is the relative efficiency for a given weight of gun improved by the substitution of staves of high elastic limit, but the boundaries of possible absolute efficiency are enlarged.

I wish, however, to be understood as basing my claim for the superiority of staves over a tubular jacket wholly upon the characteristics of metal possible to be obtained and employed in the different cases.

Lest it should be thought that I have overlooked the fact that the jacket, as a continuous tube, may take part in resisting tangential strains, I remark that this can be the case only when the amount of wire employed, or the tension with which it is applied, is disproportionately small.

It should be stated as an undisputed point that the quality of wire employed in the construction of the specific 6-inch gun herein mentioned falls short of what is known to be an entirely practicable standard.

I must further record that the gun has not been made under my superintendence.

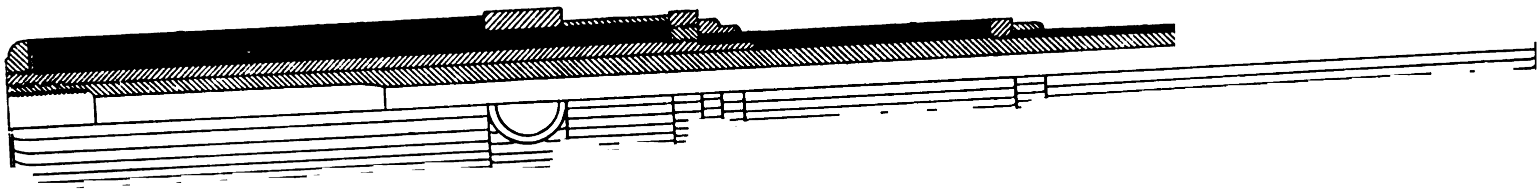
I am, sir, with sincere respect,

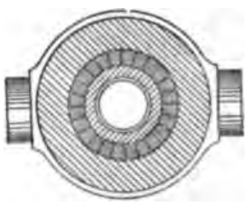
Your obedient servant,

W. E. WOODBRIDGE.

[* See accompanying drawing of 8-inch B. L. Rifle.]

EIGHT-INCH WIRE-WOUND B. L. RIFLE. W. E. W.





CROSS-SECTION THROUGH CHAMBER.

EXTRACT FROM THE MINUTES OF THE PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS, VOL. LXXVII, LONDON, AUGUST, 1884. DISCUSSION OF MR. J. A. LONGRIDGE'S PAPER ON WIRE-GUN CONSTRUCTION, PAGE 153.

Communication of W. E. Woodbridge, at the request of the Secretary of the Institution.

Dr. W. E. Woodbridge agreed with the author that it was important the question of strains should be mathematically considered, and that Mr. Brooks had treated the subject upon correct principles. It is evident, however, that calculations must be applied to ascertained data, and therefore that the experimental determination of the properties of the materials to be used in gun-construction lay at the basis of the whole subject. It was, of course, necessary, too, that all the elements of the problem should be taken into account. From the neglect of one or other of these necessities, doubtless arose what were called discrepancies between theory and practice. The calculations, of which the results had been presented in the paper, seemed to have been made without reference to the deformation of the wire (whether round or approximately rectangular), resulting from the imperfect contact of surfaces pressed together by the radial strains generated in winding. The effect of the neglect of this element in computation would be an underestimate of the strain upon the interior coils of a gun, as compared with those of the exterior. The extent of this error must be experimentally determined. This was said of guns not soldered. Evidently if the vacuities between the wires were filled with a soldering metal, the several layers would be brought more nearly into the condition of perfect contact. Perhaps a more serious oversight consisted in taking what might be called the working pressure of the gun as the point at which it was desirable that the strains on the wound wires should be uniform. The highest resistance which the materials were capable of affording was procured when the whole was brought into uniform strain at the maximum strain they were able to withstand. In providing this highest resistance as a safeguard against rupture by abnormal strains, the lesser strains of working pressures were equally well provided for. Inasmuch as steel wire of suitable size might be produced, having an elastic limit of 120,000 lbs. per square inch, while retaining an extensibility indicated by the capability of winding around a wire of the diameter of its own, diagonal dimensions, the tension of winding might be carried much higher than the author seemed to approve. True, very high tensions required from the cylinder within the coil very great resistance to the contractile effort of the wire; but this might be advantageously provided by means of the metal serving to give longitudinal strength to the gun. The author had mentioned four styles of gun-construction in which wire was employed, as having been proposed by Dr. Woodbridge to the late Board on Heavy Ordnance, appointed by Act of Congress. The one placed second on the list was briefly described, with the omission of one or two very important items, in the following words: "A steel gun, composed of an inner steel tube overlaid with longitudinal bars, and then wound round with steel wire under high tension, and finally soldered." To this it should be added that the longitudinal bars (covering about one-half the length of the tube) formed a cylinder of closely fitted staves, and that they were made of cold-wrought steel, having high elastic limits of extension and compression, while they preserved a capability of considerable elongation beyond the elastic limit. This mode of construction differed markedly from those recently essayed elsewhere than in the United States, so far as they had come to Dr. Woodbridge's knowledge, first, in providing a resistance to the constricting force of the wound-wire, so high that the tensile strain upon the latter was in no part changed to compression in winding, and that the interior cylinder was never released from ression, even in firing; and secondly, by the union of the wires by solder-

The importance attached to the first-mentioned peculiarity arose from

the avoidance of the disintegrating tendency of high reversed strains, under such circumstances as existed in this class of construction. One item of the advantages of soldering had already been mentioned, and need not be repeated.

In addition to the general solidity or resistance to displacements which it imparted to the structure, there was, in his view, a specially important feature of this kind. For the purpose of readily presenting this idea, suppose the wire could be frictionless, presenting all the other properties of a suitable gun-wire. Employing this, there would, of course, be no such possibility as varying tensions in a continuous wire, whether in the first layer or in other parts of the coil. But this, whatever might be its result, was impossible. There was, however, a momentary approach to that condition in the firing of an unsoldered wire-gun. The vibratory motions then set up partially freed the wires from the restraints of friction, and they were allowed to "creep" in the direction which tended to relieve them from the heavier strain. This would have no injurious result were the strains uniform throughout the whole length of the helices which enwrapped the tube; that was to say, if pressures were the same in all parts of the bore they surrounded, for then it would amount to nothing more than an equable distribution of strains. The case was, however, far otherwise. The heavy strains near the breech sought to relieve themselves by drawing the wire in that direction, and the original tension was there impaired. This action was, of course, prevented by soldering. A very obvious addition to the advantages of the process was the security with which the ends of the wires were fastened, and the prevention of the consequences of the accidental cutting or breaking of a single wire in an unsoldered gun. Perhaps the citation of an experiment made at the Washington Navy Yard might allay the suspicion of some that the high tensions advocated might not be maintained by the wire, especially when the guns were subjected to vibrations, as in firing. A wire 0.15 inch square was extended with a tension of slightly more than 90,000 lbs. per square inch, maintained by a suspended weight of more than 2000 lbs. Fine marks were placed upon the wire 100 inches apart, and corresponding marks upon a steel rod at its side. A hard-wood hammer, actuated by the power driving the machinery of the shops, delivered blows upon the strained wire at the rate of from four hundred and fifty to five hundred per minute, during working hours, for more than two months. No yielding or elongation could be detected. Two guns of the style mentioned above were now being constructed for the United States Government, and in due time might be expected to furnish the kind of instruction that was, after all, the most convincing, namely, experimental. It was to be regretted that the author had not given an account of the trials of his 3-inch gun, to which he alluded, in support of his opinion that a cast-iron gun tube might, without disadvantage, be subjected to a compression many times exceeding that within its elastic limit. The author had referred to the results of experimental wire-gun construction in the United States, and it might be proper that Dr. Woodbridge should mention some facts in that connection. In July, 1850, he called the attention of the Ordnance Department of the United States to a plan of construction embodied in a small gun of his invention and production, its linear dimensions being one-third those of the standard 6-pounder field gun.* It was made of flat iron wire having a cross-section of one-eighth inch by one-fourth inch, wound upon an iron tube, and brazed. Before being bored to calibre or turned on the exterior, it was fired with a charge consisting of rifle-powder, a wad and leaden shot filling the tube, to make a rough test of its strength, and also for the purpose of expanding its bore so as to bring out the resistance of its metal to an extent likely to prevent further enlargement under ordinary strains. It was finished to a weight little less than three-fourths that of a bronze gun of the same calibre having he model of the 6-pounder, which was provided for a comparative test.

The reduction of weight was made by a proportionate reduction of the

* See copies of documents given in the Report of the Chief of Ordnance, 1872, p. 159.

thickness of the metal in the different parts of its length. It was subjected to several days' continuous firing, but the experiment relied on as a demonstration of its superior strength was a comparison of the resistance of the two guns to hydrostatic interior pressure. The bronze-gun was ruptured at an indicated pressure of a little more than 32,000 lbs. per square inch. The wire-gun withstood the same pressure without visible change. In 1862 a small steel wire-gun was made at the Navy Yard, Washington, D. C. Nineteen wires one-tenth inch square were wound at once. The bore was 2.5 inches in diameter, measured on the "lands," or 2.7 inches measured in the grooves, and the exterior diameter 5.4 inches, making the thickness over the grooves just one-half the corresponding diameter of the bore. No lining tube was used in its construction. The wire was wound on a mandrel of bronze of the same composition as the soldering metal, which commingled with it in the process of soldering and filled the space within the wound wire. The lining of the bore was therefore of the same material with the solder. The weight of the gun, exclusive of the trunnion band, was 149 lbs. The first test of this gun was made under the control of the late Admiral Dahlgren, with charges of 1 lb. of powder, and a 4-lb. projectile having an expanding metallic sabot. The inventor suggested the use of a heavier projectile, but was overruled by the Admiral. This test was carried only to the one hundred and fifth round. A tangential specimen cut from the muzzle of the gun showed a tensile strength of more than 108,000 lbs. per square inch. The gun was subsequently sent to the late Mr. Edwin A. Stevens, of Hoboken, for further trial, the manner and extent being left to his discretion. Mr. Woodbridge had not ascertained the extent of the trial by Mr. Stevens, but upon applying for the removal of the gun for the test afterward made at Springfield, Mr. Stevens informed him that he was "satisfied that it could not be burst by any charge of powder and projectile that could be put into it." In 1865, by the direction of the late General Dyer, then Chief of Ordnance, it was submitted to further test at the Springfield Armory, under command of Colonel Laidley. It was there fired thirteen hundred and twenty-seven additional rounds, the charge of powder being constantly 1 lb., and the projectiles either 7 13-16 or 10 3-16 lbs., seven hundred and ninety rounds of the former, and five hundred and thirty-seven of the latter. The following was a portion of Colonel Laidley's report: "The greatest enlargement of the bore, in the rear of the seat of the shot, caused by the one thousand three hundred and twenty-seven rounds of excessive charges, is only seven-thousandths of an inch, and there are, as yet, no indications of the gun giving way in any part." As a practical test of transverse strength this trial was one of peculiar severity. The brazed wire had no support from a lining tube, and the cross-section of its metal compared with that of the United States 3-inch wrought-iron rifle, fired with the same weight of projectile, was but as 1 to 3.8. The gun was fired from a 6-pounder carriage of old and heavy pattern, heavily reinforced with iron to give it the necessary strength; the whole weight (probably not less than 1200 lbs.), practically, as related to strain in recoil, being added to the gun at the trunnions. In accordance with the recommendation of the Chief of Ordnance, and of a Board of Officers appointed under an Act of Congress, approved June 6th, 1872, a brazed wire-gun of 10-inch calibre had been constructed under his direction at Frankford Arsenal. The fabrication of this particular gun was intended as a means of instruction and practice preliminary to the manufacture of a larger gun; but Congress had added to the work to be accomplished by means of the appropriation asked for by the Chief of Ordnance for this special work, much more largely than to the appropriation, so that it became impracticable to go on with the larger gun. The brazing of so large a mass of wire (about 15 tons) was an operation quite unprecedented, and it might be left to those who had carried out processes so widely varying from anything practiced in the arts to say how great were the ulties of executing the best laid plans in the first endeavor, and whether was a matter of surprise that the first product should fall short of perfection.

It was the gun last mentioned that fell under the author's condemnation; and it must be admitted that it was by no means a perfect specimen of its style of construction, nor was it ever supposed to be such.

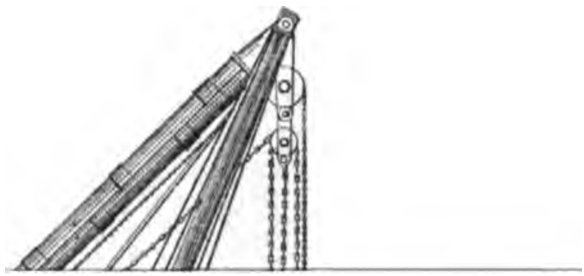
At the ninety-third round, with a charge of 80 lbs. of powder and a 400-lb. projectile, "the gun parted under longitudinal strain," said the record of the Board, "26¼ inches from the bottom of the bore." The powder employed had been selected for its "briskness," with Dr. Woodbridge's approval, and the pressure recorded by the "Woodbridge" gauge, being used alternately with the "Rodman," was 74,400 lbs. per square inch, or, as properly stated by the Board, "about 80,000 lbs. per square inch as measured by the Rodman gauge." Briefly, the defect of the gun was imperfect brazing, consequent upon insufficient heat at the lower, or breech, part of the gun. Bronze had penetrated everywhere, not a spot being found, in cutting up the gun, which it had not reached. But the lower portion of the gun, except superficially, had been brazed only by "liquated" metal, which alone could flow at the temperature of that part of the mass. Below the plane at which the temperature precluded the flow of the bronze in its entirety, the small spaces between the wires were not perfectly filled; and immediately below that plane the interfused bronze held its position, so far as was possible, only by capillary action, until it cooled. It was in this plane of most incomplete brazing that the gun parted. Notwithstanding this result, the abundant heating-capacity of the furnace and the reliability of the tests of the temperature of the different parts of the gun, when properly adjusted and employed, were demonstrated; and no room for doubt was left, at least in his mind, that the original plans, fully carried out, would have assured complete success. One important feature of the construction of this gun seemed to have been overlooked by the author, who evidently regarded it as a specimen in which the wire had no initial tension. He might have learned from the source of information to which he referred that the gun was cooled from the interior, and that the indications of initial strain, manifested by the compression of the interior, were most clearly given. The bore was contracted, as the result of firing, even at the seat of the charge. Any discussion of the relative advantages of this mode of construction would extend this communication too far. It might be permissible to add that the late Board on Heavy Ordnance, who unanimously recommended the construction of two styles of gun presented by him, also recommended, by a majority vote, the fabrication of a brazed wire-gun.

A NEW AND POWERFUL DERRICK.

HENRY H. GORRINGE.

The accompanying drawings show the general arrangement of a novel pair of shears which I have designed for the American Shipbuilding Company, and which were erected about six months ago, in Philadelphia, and have been in constant use ever since. These shears have a maximum lifting capacity of 150 tons, a swing of 36 feet clear of the wharf, and a lift of 86 feet above mean-tide level. The stone foundation is laid in cement, and contains altogether 6962 cubic feet of masonry, weighing 522 tons. The back leg of the shears is operated by a screw working in a composition nut. The screw is made of the best mild steel, 6¼ inches in diameter, 40 feet long; the nut is 27 inches long, and is encased in a cast-iron guide-shoe. The weight of the screw is supported by four movable bearings, two on either side of the nut, so arranged that the screw is always supported at least in two places. The thrust is taken up by a bearing with 10 composition rings. The back leg is 30 inches in diameter and 134 feet from centre to centre, and is made of flange-iron plates $\frac{7}{16}$ inch thick. The circumferential seams are butt-strapped with $\frac{7}{16}$-inch plates, and riveted with six rows of rivets. The back leg is supported by a truss, as shown in the engravings.

The front legs, or shears proper, are made of Phœnix columns 15 inches in diameter, formed of eight sections and stiffened with steel rods, as shown in the drawing. The hoisting machinery is a windlass driven by double engines, with cylinders 12 inches in diameter and 14-inch stroke, supplied with steam by a boiler 5½ feet in diameter and 12 feet high, carrying 90 pounds pressure. The windlass is designed to operate simultaneously or separately, six barrels, and is provided with very efficient brakes and lowering gear. The main purchase is composed of six parts of 1¾-inch stud chain rove through three-fold iron blocks. Besides this, there are two smaller single purchases, each capable of lifting 10 tons, for use in masting vessels and handling comparatively light articles. The strains are computed for lifting 150 tons, with the factor of safety of not less than 5 in every essential part. The increasing size and weight of marine steam engines and boilers, and of ordnance, demands more powerful lifting machinery than hitherto erected in this country, and it is in my judgment advisable to erect shears powerful enough for all purposes of modern marine architecture.



base of the projectile at the instant of maximum pressure, then, since the pressure would be suddenly applied to the gauge at this point, it would, by a well known mechanical law, indicate just double the pressure shown by a gauge in the chamber, where the same pressure would be reached with relative slowness.

RECHERCHES THÉORIQUES SUR LE CHARGEMENT DES BOUCHES À FEU; PRÉCÉDÉES DE DEUX MÉMOIRES SUR UNE FORMULE MONOME DES VITESSES DANS LES ARMES ET SUR UNE FORMULE DE LA PRESSION MAXIMUM. Par M. Emile Sarrau, Ingénieur en Chef des Poudres et Salpêtres. Paris: Gauthier-Villars, Quai des Augustins, 55, 1882.

M. Sarrau, in the first of the two mémoires, shows how the formula for muzzle velocity, given in his Recherches sur les Effets de la Poudre dans les Armes, a translation of which has already appeared in the Proceedings of the Naval Institute, may be reduced to a monomial form, requiring the determination of a single constant only to make it numerically applicable. The usefulness of such a formula is evident when we recollect that, with any sample of powder, only one experiment connecting muzzle velocity with the variables of loading is ordinarily available. The formula, which, of course, is less general in its application than that from which it is derived, is tested by M. Sarrau, by applying it in varying conditions, with most satisfactory results; the average value of the difference between calculated and observed results being about 15 feet-seconds.

In the second mémoire it is pointed out that the formula for maximum pressure given in the Recherches sur les Effets de la Poudre is slightly misleading, since, as it is established from considering the maximum acceleration of the projectile, it represents, not the pressure on the breech-plug, but that upon the base of the projectile. M. Sarrau is thus led to modify this formula, making the maximum pressure proportional to the $\frac{3}{4}$ths power of the weight of the charge of powder, instead of the $\frac{1}{2}$ power of that quantity. The most important and interesting part of this new work is, however, the Recherches Théoriques sur le Chargement des Bouches à Feu. This rounds out and renders complete M. Sarrau's remarkable original studies in a most difficult and complex subject. Stranger things have come to pass than that, without a long and costly series of experiments, we should be able to obtain the greatest muzzle velocity a gun is capable of safely giving; and it is certain that Sarrau has gained the honor of being the first to determine the *form of the laws* connecting this and other elements. Besides the extension of the formulae for velocity and pressure, it is here indicated how these formulae may be used in designing guns, and such questions as the following are proposed and numerically applied to certain guns: (1) Calculation of the initial velocity and maximum pressure in a gun in given conditions of loading, with a powder whose characteristics are known; (2) determination of the characteristics of a powder; (3) study of an existing gun; (4) determination of interior dimensions, conditions of loading and powder to adopt, to obtain, with fixed values of the calibre and weight of projectile, an assigned initial velocity and maximum pressure; (5) determination of the interior dimensions and conditions of loading to adopt in order to obtain, with the same powder in different guns, an assigned initial velocity and maximum pressure.

TRAITÈ THÉORIQUE ET PRATIQUE DE LA RÉGULATION ET DE LA COMPENSATION DES COMPAS AVEC OU SANS RELÈVEMENTS. Par A. Collet, Lieutenant de Vaisseau, Répétiteur à l'École Polytechnique.

The author takes for his "guide, base and model" the Admiralty Manual for the Deviation of the Compass, of which he had published a translation twelve years before. This work differs from the Manual chiefly in emphasizing

or establishing the *necessity* of the compensation of the compass, or the reduction of the five coefficients to insignificant values, and in treating at length the methods of obtaining these coefficients, and of compensating the compass without bearings. Such methods must be of very great value in times of fog, when neither terrestrial nor celestial bearings can be obtained. Starting with an introduction in which is given a brief explanation of the principles of mechanics and physics needed for the perfect comprehension of the subject, the author proceeds to the causes of, and the formulas for, the deviation and their application to the movement of the compass rose; the calculations of the approximate coefficients by means of observations of deviation solely; the explanation of the magnetic forces which act on board and their relation to the exact coefficients; and graphical methods for finding the deviation and directive force of the compass. Then follow the principles of, and practical details for, the compensation, with a description of Sir William Thompson's compass and practical instructions for its compensation. Finally, the regulation and compensation of the compass without bearings, by means of Sir William Thompson's "deflector" and by the compass corrector of M. J. Peichl are treated of. The treatise is composed of two distinct parts. One is addressed to those who wish to know the principles and the laws governing the deviation and the compensation of the compass; the other is entirely practical and can be comprehended by all mariners who possess the first elements of the theory of their profession.

Guide Pratique de la Compensation des Compas avec Relèvements.
Guide Pratique de la Compensation des Compas sans Relèvements.

These two practical guides by the same author for the compensation of the compass, the first by the method with, and the second by the method without bearings, are based on the larger work, but the matter is simplified for the use of practical men.

of the Dijmphua. The catastrophe in Sunda Straits (cont.). Additions to the sailing directions for the coast of Upper Guinea. Typhoon in Hong Kong in July, 1883. Report on trial of marine chronometers, winter of 1883-84.

PART VI. The harmonious analysis of tide observations. Report on trial of observation watches in the winter of 1883-84 by the Imperial Observatory at Wilhelmshaven. Magnetic influences on the rate of chronometers. Magnetic elements of various places in South America and the West Indies. Determination of the elements of the earth's magnetism in Tokio. Microscopic examination of volcanic dust. Review of the comparative heights of European seas. Longitude determination of important coast points. Establishment of a meteorological and storm-warning system on the coast of China.

PART VII. The catastrophe in Sunda Straits (conclusion). Surveying report of the Hyäne on certain islands of the Pacific. Samoa, Tonga and Marshall Groups, Ellice, Gilbert and Pleasant Islands and New Ireland. Port Arthur in Northern China on the Bay of Korea. Remarks on chronometers. Harmonious analysis of tide observations (cont.). Preliminary report on results of the German polar expedition at Royal Bay, South Georgia.

PART VIII. Remarks on chronometers. Harmonious analysis of tide observations (cont.). Results of German polar station at Kuigawa Fjord, Cumberland Gulf, Baffinsland. Adoption of a common prime meridian and universal time.

PART IX. The indirect or approximate solutions of the two-altitude problem, giving a review of the especial approximation methods of Douës 1754, Borda 1771, Lalande 1793, and Sumner 1837. Coast of Upper Guinea from the Los Islands to the Cameroon River. Harmonious analysis of tide observations (cont.). Notices on the Greeley North American polar expedition, 1881-1884. Deep-sea soundings of the French ship Romanche in the Atlantic ocean, 1882-83. Apparatus for the determination of velocity and direction of currents.

PART X. The indirect or approximate solutions of the two-altitude problem (cont.). Sailing directions for the roads of Sulu and Maimbun (Sulu), and the harbor of Sandakan (Borneo). Deep sea soundings of the Italian corvette Vettor Pisani in the Mediterranean and Atlantic, and of the Albatross in the West Indies and North Atlantic. Harmonious analysis of tide observations (cont.). Proposed use of acoustic signals for course determination in foggy weather. Sidney Island, Phœnix Group, South Sea Islands. Magnetic observations in and near Iceland.

PART XI. The indirect or approximate solutions of the two-altitude problem. Additions to the hydrography of the Siberian ice sea. Notices on certain harbors of the South Australian coast, Port Adelaide, Wallaros, Caroline (Kingston), Victor, Augusta and Pirie. Remarks on Port Lyttleton, New Zealand. Harmonious analysis of tide observations (cont.). The mean daily variation of

the daily declination at Fort Rae. Two storms in the North Pacific ocean near the coast of Mexico. Frequency of storms at the equinoxes.

PART XII. The indirect or approximate solutions of the two-altitude problem (cont.). Additions to the description of the coast of Damara and Great Manaqua, West Africa. Harmonious analysis of tide observations (conclusion). Remarkable storms (26–29 October, 1884). Remarks on two storms in Japan, 10–16 and 24-26 August, 1884. Cruise chronicle of the ships of the German navy in service during 1884.

BULLETIN DE LA RÉUNION DES OFFICIERS.

MARCH 29, 1884. The German navy.

APRIL 5. The Schulhof gun.

APRIL 12. A practical method of estimating distances.

APRIL 19. The electric gun.

JULY 12. Repeating rifles, continued, July 26.

ENGINEER.

JULY 4, 1884. Torpedo boats for the Russian government. The Brazilian iron-clad Riachuelo.

"This is one of the most successful war ships constructed, the performance of her engines is especially noteworthy." She is 305 feet between perpendiculars, with an extreme breadth on water line of 52 feet; depth 21¾ feet; draft 19½ feet; displacement 5700 tons at load-line, being per inch 31 tons. The contract called for 6000 H. P., but the results of the official trials indicated an average development of 6900 H. P.; the mean speed attained was, with natural draft, 16.2 knots, with forced draft, 16.7 knots. While the vessel was designed to make 15 knots with 6000 H. P., she actually attained this velocity with 4500 H. P.

AUGUST 1. Report of the U. S. Gun Foundry Board (review).

AUGUST 22. Light-ship lanterns.

SEPTEMBER 12. The British and French iron-clad navies.

OCTOBER 3. Green's ventilating apparatus for ships. The Navy.

OCTOBER 10. The Chilian cruiser Esmeralda.

This is a twin-screw steel cruiser, 270 feet long, 42 feet beam, 18½ feet draught, and nearly 3000 tons displacement. Her lower deck, of 1 inch steel, is strongly arched in athwartship direction, having a curve of about 4 feet. There are two independent sets of compound engines, and upon trial it was found that with one engine and one screw working, the ship could be kept on a course with a very small helm angle. The mean speed declared as a result of the trials, was 18¼ knots, with an indicated H. P. of 6500. With 600 tons of coal on board it is calculated that the Esmeralda can go 6000 knots at a ten knot speed, and 8000 knots at an eight knot speed. Her moderate length and good rudder power make her a very handy ship, and she has a powerful ram bow. With hydraulic gear the helm can be put hard over in from twelve to fifteen seconds when going ahead at full speed. She carries two 10-inch and six 6-inch B. L. Rifles, besides a number of machine guns.

Linked shells. The Maxim automatic gun. Shipbuilding by contract for the Royal Navy.

OCTOBER 17. The unarmored navies of England and France. Williams' electrical torpedoes and system of coast defence.

OCTOBER 24. The defence of our coaling stations. The heavy gun question in America. Experiments against armor in Spezia.

NOVEMBER 21. Education in the science of naval architecture.

DECEMBER 5. Recent Spezia trials and hard armor.

In the trials, October 1, 1884, the plates were about 19 inches thick; the steel Krupp projectile weighed 1841 pounds. The striking velocities on the Cammell, Brown, and Schneider plates were 570, 567 and 567 metres, or an average of 1864 ft. sec. The average striking energy was 44,340 ft. tons, which with the 17-inch projectile ought to perforate 30 inches of iron. It is needless to add that the plates were perforated and broken up, and the only question as between them seems to be as to which offered the most resistance.

ENGINEERING.

JULY 4, 1844. Secondary batteries. Engines of the Spanish gunboat Eulalia.

JULY 11. Guns in turret ships.

JULY 25. Longridge's wire guns (review). Secondary batteries (continued). Engines of the S. S. Arabian.

August 1. Nordenfeldt machine-guns (review). Guns in turret ships (concluded). Jury rudder of the Knickerbocker.

AUGUST 8. The 6-pounder Hotchkiss gun for the British Navy.

A number of these guns have been ordered for use in the English Navy; the gun is made of Whitworth's fluid-pressed steel, oil tempered. The body consists of a tube and a jacket carrying the breech and trunnions, so that the longitudinal and transverse strains are divided. The jacket is shrunk over the tube, and to prevent any slipping they are locked together by a screwed collar, carrying the foresight. The gun is 8 feet 1½ inches long, weighs, complete with pedestal, 15.3 cwt., and is of 2¼ inch calibre. The projectile, either shell or canister, weighs 6 lbs., and the charge is 29¾ oz. The gun is mounted on a non-recoil pedestal and is fitted with a shoulder piece and a pistol grip; it is served by two men.

The corrosion of marine boilers.

AUGUST 29. Engines for the German despatch vessel Blitz.

SEPTEMBER 5. Anchor gear for the Riachuelo.

The anchors of the Riachuelo weigh 66 cwt. each, and are of cast-steel in several parts, without stocks. The only way to make them lose their hold is by bringing the shank into a vertical position. Their peculiar form enables their shanks to be drawn with the cable completely within the hawse-pipe, the outside of which is enlarged for housing the flukes, and the lower part of the hawse-pipe is so formed that the anchor houses itself. All that then remains is to lower the buckler and the anchor is secured, without the use of catheads or fishdavits. The invention was designed by Mr. S. Baxter, whose weighing gear has also been adopted. In a time trial both anchors were let go, weighed and stowed again in forty-five minutes. The results have been so satisfactory that the English Government has ordered this system to be adopted for several of the new armored vessels.

The corrosion of marine boilers.

SEPTEMBER 19. The construction of ordnance.

OCTOBER 10. The armature of the Ferranti dynamo. The state of the Navy.

OCTOBER 17. The Clerc and Bureau dynamo. The engines of the Fish Commission steamer Albatross. The state of the Navy. Williams' system of torpedo attack and defence.

This seems to be an auto-mobile torpedo boat similar to the Lay, but with the substitution of electricity for carbonic acid as a motive power.

OCTOBER 24. The state of the Navy. The 100-pounder Armstrong gun.

A brief account of the trial of this gun, at Spezia, October 1, against the Brown, Cammell, and Schneider plates.

OCTOBER 31. The Castalia hospital ship and tender.

NOVEMBER 7. The Maxim machine gun.

In this gun there is but one barrel, and all the functions of loading, cocking, firing, withdrawing and ejecting the empty shell are performed by the recoil. The cartridges, 333 in number, are placed side by side in a canvas belt; one end of this belt is connected to the arm and the gun is worked by hand until the first cartridge is driven into the barrel. Then the gun is fired, and by the recoil the gun is reloaded and fired. The firing may therefore be kept up automatically as long as there are any cartridges in the belt, and the gun server is free to give his undivided attention to the pointing. Should a cartridge miss fire, a complete revolution of the hand wheel used in starting the gun throws out the obstacle and the automatic action is resumed. The gun is about three feet high and five feet long, and it can be set to fire any number up to 600 shots per minute. No official trials have as yet been made.

NOVEMBER 14. The electric light on shipboard.

NOVEMBER 21. Gun factories in France.

This is the title of an article giving extracts from, and a few comments upon, No. 4, Vol. X, of the Naval Institute Proceedings.

NOVEMBER 28. Electricity in theory and practice.

A review of a book so entitled, by Lieut. B. A. Fiske, U. S. N.

Our ironclad navy.

DECEMBER 5. The steamboat equipment of war vessels, continued December 26.

FRANKLIN INSTITUTE JOURNAL.

MAY, 1884. Petroleum as a source of emergency power for war ships, by P. A. Engineer N. B. Clark, U. S. N.

The author advocates the use of petroleum in the new cruisers in conjunction with anthracite coal; the latter for ordinary passages, the former for emergencies.

Tanning linen.

A Belgian inventor, M. Piron, has invented a method of rendering cellulose tissues impermeable and durable without injuring their flexibility or greatly increasing their weight. He uses the green tar of birch bark dissolved in

alcohol, which penetrates the capillary vessels of tissues, enabling them to resist the corrosive action of acids, sea water, and change of temperature. Microscopic vegetation cannot grow; while the prepared substances can be folded without breaking the fibre. The solution can be applied for the preservation of sails, awnings, cordage, etc.

JULY. Heat of combustion of coal, by Chief Engineer Isherwood, U. S. N. Physical and chemical tests of steel for boiler and ship-plate for the U. S. Government cruisers.

OCTOBER. Development of the theory of the steam engine, and its application, by R. H. Thurston.

Tide gauges.

Of late years automatic instruments have been very generally used in Europe for registering the mean level of the ocean at stated epochs. The level of the North Sea does not seem to have varied for one hundred and fifty years. The level of the Baltic is the same as in 1826. The French commission charged with this work has undertaken operations that will surpass in extent every previous thing of the kind. In Belgium, measurements have been made in 8477 places. The Spanish operations have shown that the level of the Atlantic at Santander is 0.582 metre above that of the Mediterranean at Alicante.

JANUARY, 1885. Glimpses of the International Electric Exhibition.

JOURNAL DE LA FLOTTE.

MARCH 30, 1884. The Lambinet engine counter.

The number of revolutions per minute can be determined at any instant by means of this apparatus.

MAY 18. The use of electric accumulators for the navigation of vessels.

MAY 25. The electric signal-light apparatus used in the French Navy.

The lights, five in number, are carried either upon the mizzen or main mast; each is connected by a flexible cable to the commutator; the latter, though of complicated structure, is of easy management. It allows one or more of the five lights to be illumined, and at the same time it shows on the key-board a scheme of the signal made; when the signal is extinguished the scheme disappears by the same movement. Each light is of 30-candle power; the apparatus has been used successfully on board the Richelieu, and it is intended to fit it to other men-of-war.

AUGUST 10. Extract from the report of M. de Lesseps on the Panama canal.

AUGUST 17. The Minister of Marine orders that in future the use of *tribord* and *bâbord* as applied to the helm shall be discontinued. The commands to be substituted are *à droite* and *à gauche; comme ça* will mean "keep her head as it is," and *zéro* will signify "put the helm amidships."

AUGUST 24. The Toselli submarine explorer.

SEPTEMBER 14. The electric light on board the Richelieu.

There are 227 Edison lamps on board divided into seven circuits, viz: day, of 68 lamps; night, of 79; fighting, of 16; machine, of 26; sea, of 22. All the 211 preceding lamps are of 8-candle power. The remainder, of 30-candle

power, are divided into two circuits, six running lights and ten signal lights. Felt washers are interposed between the supports and the timbers of the ship, and the lights are attached to the supports by springs to lessen the vibrations due to the revolution of the screw and the shocks from firing the guns. The seven circuits are connected with a key-board which permits any one of them being lighted or extinguished at will; furthermore, in each circuit, certain ones of the lamps are furnished with individual commutators provided with special keys. The last two circuits mentioned have a special return wire so that they can always be separated from the rest. The conducting wires are so distributed that no lamp has more than one volt less potential than at the key-board. The gramme dynamo is used; with 25 horse-power it can make 580 revolutions and light 400 lamps of 8-candle power; it occupies a space less than a metre square and about a metre high. E. M. F., 51 to 52 volts, internal resistance, .008 ohm, current 200 to 250 ampères; the derived current absorbs 22 ampères.

SEPTEMBER 28. The report of Admiral Lespès concerning the attack on the Kee-Lung forts.

OCTOBER 5th and 12th. Rules for the prevention of collisions.

By a decree of the President of the French Republic the regulations adopted in November, 1879, for the prevention of collisions at sea are abrogated and a new set enacted to date from September 1, 1884. The only important change is that vessels engaged in laying or picking up a telegraphic cable are to carry at night a red, a white and another red light vertically instead of three red lights, and by day a white diamond, made from two inverted cones, between two red balls. A new article, No. 27, is added prescribing the signals to be made by a vessel in distress; in addition to the recognized signals a burning tar or oil barrel will denote an appeal for help.

OCTOBER 19. The use of steel in naval construction.

OCTOBER 26. The report of Admiral Courbet concerning the operations in the Min river from the 23d to the 30th August, 1884 (finished in the next number).

NOVEMBER 30. Hollow shafts for marine engines.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOL. XII., No. 9. Preservation of fresh provisions aboard ship. Artillery of small calibres; a history of the development of rapid firing machine guns, and a discussion of their use, by Lieutenant Lilie, Russian Navy. Fleet manœuvres in Russia, with plate. The Double Compound Engines of the ship "Arabian." Notes on the English Navy. Fleet manœuvres in the River Jade. The American Expeditions for the exploration of the Atlantic and Indian Oceans; an account of deep sea soundings taken by the U. S. S. Enterprise and the U. S. C. & G. S. S. Blake. Rubber cross-wires for astronomical and geodetic instruments.

VOL. XII., NO. 10. The relative movements of fish torpedoes; a mathematical discussion by Captain Julius Heinz, Royal Austrian Navy. Experiments with Naphtha as a fuel (trans.). Experimental Firing at Juchheit. New Spanish 16 cm. Steel Naval Gun. Experiments with 6-pdr. Hotchkiss Rapid Firing Cannon. The engines of the new German dispatch vessel Blitz. Use of oil to break the force of waves. A new under-water torpedo boat. A new material for shipbuilding.

VOL. XII., NOS. 11 and 12. The use of rolled, cast and wrought steel in shipbuilding. The Ram. The electric light, and electric apparatus for night signalling, on board the French ironclad Richelieu. Different methods of measuring gas pressures in guns. Penetration of projectiles against wrought iron and wooden walls. French operations in the river Min. Austrian Naval Budget for 1885. A course-finder, an instrument devised by Captain Martinolich, of the Austro-Hungarian Lloyd Company. Notes on the Russian Navy; (new vessels for the Baltic; the Renaissance of the Black Sea Fleet; the new dry docks at Sebastopol; Russian Naval Budget for 1885). Telegraphic communication of fire ships with the shore.

MILITARY SERVICE INSTITUTION OF THE UNITED STATES, JOURNAL.

SEPTEMBER, 1884. The military necessities of the United States, and the best provisions for meeting them (prize essay), by Lieutenant A. L. Wagner, U. S. A. The same (first honorable mention), by Captain O. E. Michaelis, U. S. A.

JANUARY, 1885. The same (second honorable mention), by Major W. A. King, U. S. A.

REVUE MARITIME ET COLONIALE.

SEPTEMBER, 1884. A contribution to the geometry of naval tactics, by Lieutenant Vidal, French Navy. Organization of the Norwegian Navy (translation). The English Naval Budget for 1884-5 (trans.). The administration of the navy—hospitals and prisons.

ROYAL UNITED SERVICE INSTITUTION. 1884.

NO. 123. The necessity for the systematic training of naval officers in the art of manœuvring ships under steam. The present position of the armor question. Distribution of the personnel of the navy on an outbreak of war (prize essay).

NO. 124. The ram in future naval victories.

NO. 125. On libraries considered as subsidiary to naval education.

NO. 126. The Yarrow torpedo boats. Discussion on the naval prize essay. The heavy guns of 1884. Fog collisions. A new stability apparatus.

TESTS OF ARMOR—SCHNEIDER & CO., Creusot, France.

Through the courtesy of M. Henri Schneider we have received a portfolio of photographs and a collection of illustrated pamphlets, some of them being papyrographs, illustrating and describing the experiments made for testing armor plates, both at Spezzia and Gâvre, from 1876 up to 1884. In addition to these are descriptions of the methods for fastening armor plates, an historical memorandum of the Schneider and compound plates, and trials of projectiles against armor. It is unnecessary to criticise here the results shown in these

pamphlets, for the experiments have been already widely noticed and commented upon in the various technical journals, but it would be difficult to find anywhere so complete a record of the experiments, or one in which the illustrations are so well executed. The Institute congratulates itself both on the intrinsic value of a donation so thoroughly appreciated, and the compliment conveyed in the fact that it was entirely voluntary.

COURSE IN PERMANENT FORTIFICATION, 1 Vol. COURSE IN TEMPORARY FORTIFICATION, 1 Vol. Captain James Chester, 3d Artillery, U. S. Army, Fort Monroe, Virginia. Artillery School Print.

These pamphlets are the authorized text-books at the Artillery School, being used in the course of instruction for the officers detailed from the army.

We have received from the American Machinist Publishing Co. a bound volume of the *American Machinist* for the year 1884. This journal, issued weekly, is devoted to the interests of mechanical engineering, and its columns are replete with the latest examples of modern practice. The thanks of the Institute are tendered for this generous contribution to its library.

ADDITIONS TO LIBRARY.

EXCHANGES.

American Geographical Society, Proceedings. No. 3.

American Institute of Mining Engineers, Transactions. Vol. XII., 1884.

American Iron and Steel Association, Bulletin. Nos. 12–42.

American Philosophical Society, Proceedings. Vol. XXI., Nos. 115, 116.

American Society of Civil Engineers, Transactions. Nos. 272–289.

American Society of Mechanical Engineers, Transactions. Vol. V., 1884.

American Chemical Journal. Vol. VI., Nos. 1–5.

Annalen der Hydrographie und Maritimen Meteorologie. Parts 3–12.

Connecticut Academy of Arts and Sciences, Transactions. Vol. V., Part I.; Vol. V., Part II.

Geographical Society of the Pacific. 10 Pamphlets, On Arctic Drifts and Ocean Currents, the Magnetic Pole, and the Shoaling of the Bar at the entrance to San Francisco Harbor.

Giornale di Artiglieria é Genio. Nos. 2–12.

Institute of Mining and Mechanical Engineers, Transactions. Vol. XXXIII, Nos. 3 and 5.

Institute of Mechanical Engineers, Transactions. Nos. 1–4.

Institution of Civil Engineers, Proceedings. Nos. 3, 4.

Journal de la Flotte. Nos. 12–51.

Journal of the Franklin Institute. Nos. 697–709.

Journal of the Military Service Institution of the United States. Vol. V., Nos. 18, 19, 20.

Journal of the Royal United Service Institution. Nos. 125, 126.

Mittheilungen aus dem Gebiete des Seewesens. Vol. XII., Nos. 3–12.

The Mechanical Engineer. Nos. 7–14.
Norsk Tiddskrift for Sovaesen. October, November and December, 1884.
Reunion des Officiers, Bulletin. Nos. 11–51.
Rivista Marittima. Nos. 3–12.
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NAVAL INSTITUTE PRIZE ESSAY, 1886.

A Prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1886. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute, and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control, and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *What changes in organization and drill are necessary to sail and fight most effectively our war-ships of the latest type?*

7. The Essay is limited to forty-eight printed pages of the "Proceedings of the Institute."

8. The successful competitor will be made a Life Member of the Institute.

9. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

ROBERT W. ALLEN,
Secretary and Treasurer.

ANNAPOLIS, MD., *February* 13, 1885.

men. No leave to go on shore from the day the ship was in commission until paid off. No wages until paid off, but occasionally prize money. The ship filled with prostitutes at every port, by permission of the commanding officer. Not many years ago (it was since 1840) the captain of a frigate in a West Indian port (Barbadoes) gave an order to the first lieutenant that every man and boy was to have a black woman on board, and the order was carried out; but that was, at that date, an exceptional case. The majority of the able and ordinary seamen and many petty officers got drunk on every opportunity, viz. when their boats went on shore, or by smuggling liquor on board, or by saving up their daily allowance. Flogging was a weekly, almost daily occurrence. It was almost certain that somebody would be drunk at evening muster, and the punishment was flogging at 11.30 next forenoon. The men could, as a rule, neither read nor write. They were brave as lions, and generous, if utter recklessness with their money when they got it could be called generosity. After a three years' commission, men have received from £60 to £100 of pay alone, irrespective of prize money. As a general rule they lost all their money the first night after the ship was paid off, and the penniless men re-entered for another term of service. Such was a seaman's life: but all this is now changed." This picture of the English man-of-war's-man is a little worse, perhaps, than can be, or ever could have been, truthfully shown of our seamen or of our men-of-war, but the general characteristics as to the sailor are correct. With us the change has been slight, and I am sorry to say that even now the sailors in the United States Navy are among the worst drunkards in the world.

The man-of-war's-man is only an American for the time being, for the dregs of all countries seem to get into our service. The character of the men now obtained is somewhat improved over former years, but there is still much room for improvement. This description of a sailor answered well enough for their time, because the then sailing vessels were directed by the officers: sailors were wanted more for their strength than intelligence. The guns were not instruments of precision, it was mere chance if they hit anything with the shot, except at short range. Would such men do for a modern man-of-war? Most emphatically, no. The improvement most needed in our seamen is not in bravery or fortitude, but in character and general intelligence. The vessels themselves are instruments of precision; while the cannon now carried are delicately sighted and carefully ranged,

heavy in caliber and few in number, which makes it essential that no ammunition should be wasted. Neither could a drunken, stupid man be in any way intrusted with the management of guns, their machinery, or the machinery that propels the vessel; to say nothing of the improved small arms, electrical apparatus and torpedo gear.

Quoting again the words of Admiral Ryder, R. N., "A man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, an experienced machinist, and a superior torpedoist, rolled into one."

In order to properly discuss the subject of the essay it will be well to define what is meant by the term Seamen, how they are obtained at present, and who compose that class in our navy.

Fifty years ago the answer could have been more readily given than now. Then, men-of-war consisted entirely of sailing vessels; now, sailing vessels are the exception. The crew of a monitor without any sails are considered seamen in the eye of the law, as much as the crew of a training ship with only sail power, though it is evident that there is a wide difference in their duties. Strange as it may seem to a non-professional, classed among seamen are landsmen. On board of a man-of-war, all enlisted persons, except marines, come under the general head of seamen. In law, the definition of a seaman is "Any person whose employment is necessary, or whose service is useful, in the navigation of a vessel."

Section 1417, U. S. Revised Statutes, provides that the number of persons who may "at one time be enlisted into the navy of the United States, including seamen, ordinary seamen, landsmen, mechanics, firemen and coal-heavers, and including seven hundred and fifty apprentices and boys, hereby authorized to be enlisted annually, shall not exceed eight thousand two hundred and fifty." They can be classified as follows:

1st. *Sailors.*

Those who man the guns, handle the sails, steer the ship, and man the boats, which would include: Petty officers, captains of the different parts of the ship, gunner's mates, quarter gunners, boatswain's mates, coxswains, quartermasters, seamen.

2d. *Mechanics.*

Carpenters, machinists, boilermakers, painters, blacksmiths, coppersmiths, sailmakers.

3d. *Firemen and Coal-heavers.*

4th. *Cooks, Stewards, and attendants.*

5th. *Marines.*

The questions to be discussed in this essay are understood to be limited to: 1st. Sailors; 2d. Mechanics; 3d. Firemen and Coal-heavers.

At present, these men are obtained by enlistment. The recruit being required to be sound physically, between certain ages, and to be able to reef, furl and steer, for the rate of seamen. Firemen and coal-heavers to be competent for these rates. Machinists, blacksmiths, boilermakers and coppersmiths, may be enlisted as such; but all other petty officers are enlisted as seamen or landsmen, except a petty officer holds three continuous honorable discharges as such, in which case he is enlisted as a petty officer.

Seamen enlisted in this way cannot be called trained seamen, in the sense that they owe their training to the United States Navy. A very few of those who thus enlist were apprentices; these are trained seamen, and as I understand the problem, the question refers only to retaining these.

Why so few re-enlist, we must suppose, is because the inducements are not great enough. Let us inquire what these inducements are. Appended will be found the "Shipping Articles." The first, that for an apprentice; the second, for a recruit of age.

The only inducements here held out are the amount of wages the recruit is to receive, and that if he re-enlist under a continuous-service certificate he will receive one dollar a month additional pay for each re-enlistment of three years. It does not tell him that this certificate is a matter of regulation, not law, and its terms may be changed or the whole thing done away with at the convenience of a single person. He is, however, to obey all laws and regulations then in force and that may be established during his term of service. Are these laws and regulations read at once to the recruit? Or does he have a copy given him that he may ponder over them at his leisure before enlistment? I think no one can reply in the affirmative. It is true, on board of men-of-war it is required that certain extracts of laws governing the navy are to be hung up on the berth deck, and the "Articles for the government of the Navy" are read on the quarter-deck at muster, once a month. These, however, relate to penalties rather than to privileges.

But suppose that he is told all. Let us examine what are his inducements.

I.—By Law.

(a) *Pay*, as stated on Shipping Articles.

(b) *Honorable Discharge*. Sec. 1429, U. S. Revised Statutes: "It shall be the duty of every commanding officer of a vessel, on returning from a cruise, and immediately on his arrival in port, to forward to the Secretary of the Navy a list of the names of such of the crew who enlisted for three years, in his opinion, on being discharged, are entitled to an honorable discharge as a testimonial of fidelity and obedience; and he shall grant the same to the persons so designated." Sec. 1573, *ib.*: "If any seaman, ordinary seaman, landsman, fireman, coal-heaver, or boy, being honorably discharged, shall re-enlist for three years, within three months thereafter, he shall, on presenting his honorable discharge, or accounting in a satisfactory manner for its loss, be entitled to pay, during the said three months, equal to that to which he would have been entitled if he had been employed in actual service."

(c) *Pension, for wounds or disability in line of duty*. Sec. 4693, Rev. Stat.: "The persons entitled as beneficiaries under the preceding section (4692) are as follows: *First*. Any officer of the army, including regulars, volunteers, and militia, or any officer in the navy or marine corps, or *any enlisted man*, however employed, in the military or naval service of the United States, or in its marine corps, whether regularly mustered or not, disabled by reason of any wound or injury received, or disease contracted, while in the service of the United States and in the line of duty." Sec. 4695, *ib.*: "The pension for total disability shall be as follows, namely: . . . . and for all other persons whose rank or office is not mentioned in this section, eight dollars per month." . . . See also Secs. 4756 and 4757, *ib.*

(d) *Pension to Widow and Minor Children*. Sec. 4702, *ib.*: "If any person embraced within the provisions of sections 4692 and 4693 has died since the 4th day of March, 1861, or hereafter dies, by reason of any wound, injury, or disease, which under the conditions and limitation of such sections would have entitled him to an invalid pension had he been disabled, his widow, or if there be no widow, or in case of her death without payment to her of any part of the pension hereinafter mentioned, his child or children, under sixteen years of age, shall be entitled to receive the same pension as the husband or father would have been entitled to had he been totally disabled, to commence from the death of the husband or father, to continue to the widow during widowhood, and to his child or children,

until they severally attain the age of sixteen years, and no longer; and if the widow remarry, the child or children shall be entitled from the date of remarriage."

(e) *May be Warrant Officers.* Sec. 1417, Rev. Stat.: "In the appointment of warrant officers in the naval service of the United States, preference shall be given to men who have been honorably discharged upon the expiration of an enlistment as an apprentice or boy, to serve during minority, and re-enlisted within three months after such discharge, to serve during a term of three or more years." See also Sec. 1407, *ib.*

(f) *Buried in National Cemeteries.*

II.—By Regulations of Secretary of the Navy, which can be changed or rescinded at the Secretary's will.

(a) *Continuous-Service Certificates.* Pars. 18, 19 and 20, page 100, Navy Regulations: "All men who enlist for three years, except officers' cooks, stewards and servants, will receive, upon the expiration of their enlistments, if they shall so elect, continuous-service certificates in lieu of the ordinary or honorable discharges. All persons holding continuous-service certificates will be entitled to receive for each continuous re-enlistment for three years, within three months from the date of their discharge, one dollar per month in addition to the pay prescribed for their several ratings; but a person failing to re-enlist within three months from the date of his discharge will cease to derive any advantage from his previous continuous enlistments." "The continuous-service certificates will embrace all the advantages of the honorable discharge in cases where persons are recommended for the same, and must always show, in the column for the purpose, whether or not the person is entitled to an honorable discharge."

(b) *Good-Conduct Badges.* Par. 22, page 101, U. S. Navy Reg.: "Any enlisted man holding a continuous-service certificate, who is distinguished for obedience and sobriety, and is proficient in seamanship or gunnery, shall receive upon the expiration of his enlistment a good-conduct badge; after he has received three such badges, under three consecutive re-enlistments, within three months from the date of his discharge, he shall, if qualified, be enlisted as a petty officer and hold a petty officer's rating during subsequent continuous re-enlistments; and shall not be reduced to a lower rating except by sentence of a court-martial."

(c) *Rewards.* Section 1, Par. 22, U. S. Navy Reg: "The following directions will be observed by all Commanding Officers of vessels in respect to good-conduct classes, badges, and discharges; to granting liberty on shore to ships' companies, and to the allowance of liberty-money."

I. When a vessel is fitted for sea, and has her crew on board, her Commanding Officer will at once commence to designate her crew, in the order of good conduct, in four classes, viz., 1st, 2d, 3d, and 4th.

II. This classification of the crew should be governed at its commencement by the possession on the part of the men of honorable discharges, medals of honor, continuous-service certificates, good-conduct badges, good-conduct discharges, and any other reliable information that can be obtained by reference to the Bureau of Equipment and Recruiting, or from other sources, as to the previous character of the men.

III. As the cruise progresses, such changes should be made in the classes as may be warranted by the conduct of the men, either for the better or for the worse; the general character of the men is to have its due weight, and proper consideration is to be shown to such men as have been noted for acts of gallantry during war or previous service, or during the cruise.

IV. The surest way to make men contented on shipboard, and attached to the service, is to make them feel that our ships of war are their homes, and to make it apparent to them that their interests will be well cared for while they remain in the Navy.

V. The men should also be made aware that their good conduct will entitle them to every practical indulgence.

VI. First-class-conduct men should be allowed such recreations as may be compatible with the demands of duty and with the exigencies of foreign service; and an appropriate distinction should be made between them and the rest of the crew; but this distinction should not be so marked as to excite discontent among the ship's company.

VII. First-class-conduct men should be allowed to go on shore very frequently, in ports where the ship lies convenient to the landing, and where granting liberty is unobjectionable. In such instances a portion of them might be sent on shore daily, after the work and exercises are ended, to return on board by 10 P. M.; but, on any special occasion, to have leave until a later hour.

VIII. In addition to this evening-leave, first-class-conduct men may also have, at the discretion of the Commanding Officer, liberty on shore for twenty-four hours twice a month; and, if out of debt, may also, with the approval of the Commanding Officer, draw from the Pay Officer one-third of their monthly pay, per month, while in port.

IX. Second-class-conduct men may be allowed, at the discretion of the Commanding Officer, liberty on shore for twenty-four hours, once a month; and, if out of debt, may also, with the approval of the Commanding Officer, draw from the Pay Officer one-fourth of their monthly pay, per month, while in port.

X. Third-class-conduct men may be allowed, at the discretion of the Commanding Officer, liberty on shore once in six weeks for twenty-four hours; and, if out of debt, may also, with the approval of the Commanding Officer, draw from the Pay Officer one-fifth of their monthly pay, per month, while in port.

XI. Fourth-class-conduct men may be allowed, at the discretion of the Commanding Officer, liberty on shore for twenty-four hours once in two months; and, if out of debt, may also, with the approval of the Commanding Officer, draw from the Pay Officer one-fifth of their monthly pay, per month, while in port.

XII. In ports the unhealthiness of which may render it unadvisable to send the crew on shore on liberty, such indulgence is not to be granted; and in any case, in a foreign port, the permission of the proper local authorities must first be obtained: otherwise, unless the exigencies of the service shall prevent the granting of liberty to the crew, no one of the ship's company shall be deprived of liberty on shore for more than three months, except he be confined under sentence of court-martial, or under arrest for trial by court-martial.

XVI. The requisite qualifications for first-class-conduct men are as follows: Strict attention to duty, implicit and ready obedience to orders, sobriety, alacrity, courageous conduct, neatness of person and of dress, quiet and respectful demeanor, and general usefulness. This classification will be irrespective of rating.

XVII. Second, third and fourth-class conduct men will be designated from their exhibition, in a less degree, of the qualities enumerated in paragraph XVI, or from their want of them or of any of them.

XVIII. A separate conduct-report will be kept for boys; and when boys are sent on shore on liberty they will be put under the charge of a Petty Officer, or of a Non-commissioned Officer of Marines.

XIX. At the end of a cruise, first-class-conduct men will receive their good-conduct badges before being discharged. The badge will be presented by the Commanding Officer at a special or at a general muster.

XX. Good-conduct badges are to be worn at general musters and on occasions of ceremony.

XXI. Second-class-conduct men may receive a good-conduct discharge if they have been but slightly behind the first-class requirements, and if they have shown a commendable desire to make up for any remissness in conduct; but they are not to receive a good-conduct badge. A good-conduct discharge will be of advantage as a recommendation on re-entering the service or in seeking other employment.

(d) *May become Seaman Gunners.*

NAVY DEPARTMENT, WASHINGTON, *June* 28, 1881.

General Order No. 272.

With the view to the further development of the training system, the following additional regulations will be put in force:

I. Apprentices who have been discharged with a continuous-service certificate as seamen, and who shall re-enlist for five years within three months after

such discharge, may be admitted to the gunnery school for instruction in gunnery.

II. The gunnery school will be established on board such vessel or vessels connected with the training station as may be hereafter designated, and will be termed the Gunnery Ship. To be eligible for admission into this school, the candidate must be over twenty-one years of age and not over twenty-five. His record of conduct must be unexceptionable. He must pass a first-class examination as seaman, be able to read and write fluently, and be familiar with ordinary broadside drill.

The course in gunnery shall last at least six months, and shall include progressive instruction at the different duties and stations of gun-numbers in the various crew formations adopted for general service—the duties of the gun-captain; construction and storage of magazines and shell-rooms; names and uses of the various kinds of projectiles, fuses, primers, etc., and of all the implements used in ordinary service work by the gunner's gang. In addition to proficiency in practical work, the candidate for a certificate must show his ability to station and exercise an uninstructed gun crew, and obtain a certain degree of excellence in target firing.

In small-arms he must know the use and care of such small-arms or machine guns as are supplied to the general service, with the principles of ordinary formations and manual of small-arms.

The course of instruction will also include broadswords, boxing and fencing, and the use of the diving apparatus (elective), and practical drill in laying out and handling torpedoes.

III. Seamen who have successfully passed through the prescribed course, will be given certificates as *seamen gunners*, and a pay of twenty-four dollars ($24) per month.

IV. Seamen gunners will be eligible to the rates of coxswains, captains of the tops, etc., at the current rates of pay. They will be deprived of their certificates as seamen gunners only by sentence of a general or summary court-martial.

V. Every ship carrying heavy guns will be allowed one (1) seaman gunner to each two (2) broadside guns, and one (1) to each pivot gun, as gun-captain.

VI. Commanders of vessels returning from a cruise, and having seamen apprentices on board, will, immediately upon their arrival in a port of the United States, prepare and forward to the Bureau of Equipment and Recruiting a list of such apprentices as may be eligible for admission into the gunnery school.

VII. The Bureau of Equipment and Recruiting will grant all seamen apprentices returning from a cruise the usual leave of absence, and at the expiration of their leave, those who have been recommended will be ordered to the officer commanding the training station for instruction.

VIII. Seamen apprentices who have returned from a cruise, and who have not attained their majority, will, after the expiration of their leave, be sent to the training school to serve out their unexpired terms of enlistment. When there, those properly qualified will follow a course to prepare them for sub-

sequent admission to the gunnery school. Those who have more than six months to serve will be liable to transfer to cruising vessels.

IX. It is contemplated to have the positions of all gunnery petty officers filled, in time, exclusively by selection from among those who hold seamen gunner's certificates, and to require candidates for warrants as boatswain or gunner to hold certificates as seamen gunners.

WILLIAM H. HUNT,
Secretary of the Navy.

NAVY DEPARTMENT, WASHINGTON, *December* 16, 1881.

General Order No. 281.

General Order No. 272 is modified as follows:

Apprentices who have re-enlisted under continuous-service certificates for *three years* may be admitted to the gunnery ship for instruction, subject to the conditions of paragraph II in the said Order. When they shall have successfully passed the prescribed course they will receive certificates as seamen gunners, and pay at the rate of $26.50 per month.

The pay of seamen gunners who re-enlist for three years will be $33.50 per month in addition to the longevity allowance due to the continuous-service certificate, provided, that the seaman gunner shall pass a satisfactory examination (on board the gunnery ship if practicable), and shall have received, during his service afloat, the favorable report of his commanding officer.

No seaman gunner shall receive the increased pay of $33.50 until he has served, as such, at least two years on board a sea-going vessel.

Seamen gunners may be required to perform the duties of any petty officer, with the pay of that rating, if higher than their own.

Such portions of General Order No. 272 as are not affected by this Order will remain in force.

WILLIAM H. HUNT,
Secretary of the Navy.

To have persons remain in any employment it must be made to their interest to do so. It is idle to suppose that a mechanic or laborer will not seek the highest wages, though he leaves an employer with whom he has worked for years. So in the navy, while in war times, as a matter of sentiment, men may serve their country for nothing, in times of peace no such sentiment exists, and only those remain in the navy who cannot better themselves elsewhere. In our rich country there are few persons who cannot earn a dollar a day on shore, yet there are very few men on board ship who are paid this much. The historic reply of an old man-of-war's-man when being reproached by his commanding officer for drunkenness, "that the cardinal virtues of human nature were not to be expected at $20 per month," contains the very essence of the discussion on

this point. Those on shore have all the freedom from restraint they desire, while those in the navy are always under constraint and supervision. Indeed, when given liberty on shore, they are not only subject to the civil law but to the military law, "All offences committed by persons belonging to the navy on shore shall be punished as if they had been committed at sea." A person who enlists in the navy for a term of years gives up home, friends and associations for that time; he severs for awhile his tenderest ties, and in most cases is separated by thousands of miles from those who are most dear to him. In addition, he subjects himself to the unnatural confinement on board ship. If he is so unfortunate as to be in debt, he is virtually a prisoner for this time. The discomforts of ship life cannot be understood by those who live on shore, or at best have made but a passage at sea in the luxurious steamers of the day.

"There is no title perhaps so monstrously abused in popular language and notions as that of *sailor*. To go on board of a ship and assist in making a passage across the ocean, and then to unload her and come back again, is very far from making a man a sailor. He is more of a travelling stevedore than a sailor. To sign the books of a passenger steamer and make a voyage in her from port to port, where the highest duties are to wash off the filth of emigrant passengers, does not make a sailor either. Going out on the banks of Newfoundland in a schooner to drop anchor and fish for cod, is not making a man a sailor. He is about as far from being a sailor as the cod are from being meat. Oystering and clamming are very useful vocations, but one may pursue them many years with credit and yet never become a sailor—very far from it. A man may track a tow-path of a canal all his life and even then not become a sailor. Even a three or four years' cruise round the world in a whaler does not make a sailor; it makes a very hardy, courageous fellow, but he is far from being a sailor still. Steamboat-men, on tugs, steamboats, or our Sound steamers, are not sailors, though they sometimes assume the title for its honor, and claim a usurped privilege, which is theft. Men may live on the water or near the water, or travel over it in long voyages or on pleasant excursions, and yet be no nearer the mark of a sailor than any other traveller or lounger."*

A workman or mechanic on shore works only during the limited hours of the day; a sailor's day has no end. He stands watch day

* Naval Duties and Discipline. F. A. Roe. Pp. 134, 135.

and night; never by any chance, at sea, has more than eight hours' sleep out of the twenty-four. He is liable to be, and often is, disturbed of this rest to go on deck in stormy weather and work all the night long in rain, snow, sleet and hail, with seas washing over him. When such a night's work is over he has no comfortable bed to go to nor a dry, warm room to rest in. Even Sunday, a day of repose for those on shore, is but little different from other days on board ship. The saying is very true:

> "Six days shalt thou labor and do all thou art able;
> On the seventh, holystone decks and scour the cable."

"Their lives are a perpetual combat with danger in every form; danger from accidents, if they go aloft or if they go below; danger from shipwreck, from storm, from a faulty ship; danger from air, fire, and water; danger from disease; danger from battle; danger from boat service—a service full of peril always; danger from collision; and danger everywhere."*

TRAINING SYSTEM.

It may be asked why the Training System has not supplied the navy with the required number of trained men? As early as 1840, an attempt was made to enter apprentices and thus get a better class of men for the navy. But want of system, want of encouragement, soon brought it to an untimely end. Again, in 1863, the matter was revived, under a most excellent system of regulations and management; but the inducement held out that a certain number would be appointed cadet midshipmen caused many to enter to compete for this prize, but, when disappointed in this, they either got discharged, through the influence of friends, or deserted, or remained discontented through their term of apprenticeship and never re-enlisted. Besides these difficulties, there was, for some unknown reason, much opposition to the system and boys, on the part of many of the older officers, and in consequence their position was uncomfortable in the service generally.

In 1875, Rear Admiral Shufeldt, then captain, became Chief of the Bureau of Equipment and Recruiting, under whose cognizance this branch of the service came. He, besides being a man of great intelligence and perseverance, is a great philanthropist and humanitarian.

* Naval Duties and Discipline. F. A. Roe.

Under his able administration the apprentice system was revived, and through his energy and perseverance in a few years there were more than 1000 on the books, and a fleet which formed a large part of our navy was constituted for them. The whole condition of the sailor was so much improved that desertions in less than two years fell from 1203 to 669, or about one-half, and punishments became very much less. And, for the first time in the history of the navy, men were classified and given privileges according to their conduct. (See Navy Regulations already quoted.) An attempt was also made to give uniformity in punishments. His successors have continued his work, except in one important particular, namely, laying up the ships in winter, and then having schools to give the apprentices a foundation for an education. This may be the reason so few of these apprentices re-enlist on completion of their apprenticeship. Be this as it may, one is brought to believe that something is still wanting to make the service desirable. Just how many re-enlist I am unable to say, because no statistics are published; but in the ships I have lately served, out of the 300 men only four had been apprentices.

Now there can be no doubt that the navy must be supplied with trained men, and, in a degree, educated men. It also seems evident that these men must be trained and educated from boys. If little attention is paid to the education, and the boys had a reasonable expectation to receive instruction, then the government is at fault.

Section 1417, Revised Statutes, says: "Provided, that in the appointment of Warrant Officers in the naval service of the United States preference shall be given to men who have been honorably discharged upon the expiration of an enlistment as an apprentice or boy to serve during minority, and re-enlisted within three months after such discharge to serve during the term of three or more years." This act passed Congress in 1879. If a single appointment has been made as boatswain, gunner, sailmaker or carpenter in accordance with law, the Navy Register fails to show it. I have known commanding officers to recommend deserving apprentices to be given facilities to prepare for examinations to these grades, and nothing was done. And to-day no commanding officer can give an assurance to any one under his command that they will have an opportunity of competing for such a prize. In other words, there is no standard which an enlisted man may attain which will enable him to be a warranted officer in the navy.

First then, no adequate opportunity is offered to obtain a proper education, and, secondly, if in spite of obstruction such an education is acquired, no assurance is given of the promised reward. A sober, intelligent man does not continue in a service which offers no hope for promotion.

There are an average of 8000 enlisted men in the navy. To keep this number up, there are (taking an average of a number of years as shown by the reports of the Bureau of Equipment and Recruiting) annually enlisted over 5000. Now as the term of enlistment is only three years, this number should not reach more than 3000. The casualties to make such an extraordinary enlistment necessary are made up from those whose terms of service have expired, from desertions, from deaths, and from discharges by request. The losses from death do not average more than five in a thousand.

Very few of these enlistments are of those who have served an apprenticeship. In 1879, of the 5119 who enlisted, only 620 were honorably discharged men. In 1881, of 5270 enlistments, only 434 re-enlisted under honorable discharges. The data furnished by the various reports of the Navy Department are so meagre that it is almost impossible to estimate the waste of the navy. In the British navy the waste is about 13 per cent.; that is, to keep up an average of 18,000 seamen requires an annual addition of 2400 or 2500 persons; while in our navy, to keep up 8000 requires more than twice that number, or nearer 50 per cent. This is enormous, and renders it difficult to have our ships at all efficient in crews.

The English Training System is a great success, their navy being supplied entirely from it, and for two reasons. The first is, that the class who are entered are bettered in their lot by going into the navy, and secondly, a faithful service until 38 years of age is rewarded by a comfortable pension to retire upon. Like with us, all enlistments are voluntary; as their system has been successful, it would be wise to study it, and if possible, improve upon it. Commander F. E. Chadwick's most excellent report on this subject, made in 1879, and published by Congress in 1880, Ex. Doc. 50, gives a most complete and interesting account of this system. The most striking contrast with ours is in the matter of education. I am constrained to think this neglect on our part is the chief reason why our system has had so little success.

I would recommend the following inducements for retaining trained seamen in the navy, and system of rewards for long and faithful service.

INDUCEMENTS.

1. *Opportunity to become warrant officers.*

2. *Opportunity to become seamen gunners.*

3. *To be made permanent petty officers.*

4. *Commutation in reducing enlistment terms of service for good behavior.*

5. *Honorable discharges, continuous-service certificates, medals, and bounty for re-enlistment.*

6. *An outfit on each re-enlistment.*

7. *Government savings bank.*

8. *Uniformity of privileges, indulgences and punishments.*

9. *Pension for disability received in line of duty.*

10. *Pension to widows and minor children.*

REWARDS.

11. *Pension after twenty-one years' service after attaining majority.*

12. *Employment in life-saving service.*

13. *To be enlisted for special service on receiving ships.*

14. *Preference given for employment in navy yards and stations.*

In giving directions for cooking a hare, a certain cookery book says it is necessary first to catch the hare. So in this discussion. I propose first to catch the seaman.

Opportunity to become Warrant Officers.

From the description given of a sailor's life, it is evident that an essential to contentment on board ship is to have few ties on shore. Apprentices should be enlisted between the ages of fourteen and sixteen. They should serve in the training squadron until eighteen, and then sent to cruisers to serve until twenty-one. In order that they may hold their own on board of cruising vessels, they should be sent in detachments of not less than fifty. While in the training fleet they should serve one-half of each year at sea; the other half should be spent at the headquarters of the training service. The time not spent at sea should be devoted to instruction in reading, writing and arithmetic, the foundation of learning; and such drills and practical work as may be required to fit a lad for the service.

There should be a machine and carpenter shops at the station as

well as a rigging and sail loft. Should an apprentice be found capable of being farther advanced in his studies, every aid and encouragement should be given him. Should it be ascertained that an apprentice has an aptitude for a machinist, carpenter, or sailmaker or boatswain, his bent in these directions should be developed by additional opportunities in these shops. When they are sent to sea at eighteen, full particulars should be sent with them of any specialty they may have, and their commanding officer be directed to encourage and aid them.

Competent schoolmasters or junior officers should be sent with every detachment, and those apprentices who wish to continue their studies should have the opportunity.

If possible, boys from our cities whose parents are dead and the children of poor people should only be enlisted. These lads would be so much better off in the navy than they were before that they would be more attached to it than lads from the country or the intractable sons of parents well to do. In two years a lad of very ordinary capacity could be taught to read, write and cipher, so that they would require to know very little to commence their naval career. To supply the waste of the navy it will be necessary to have one thousand enlisted annually for the next ten years, and then a reduction of one hundred per year till the number of enlistments is reduced to five hundred per year.

In enlisting apprentices, not only have lads been taken from the seaports, but from the interior, even from Western country—boys from farms, boys from printing offices, and boys who were intractable at home. Altogether they made a fine lot; they did not lack intelligence, they generally behaved well on board ship, and in fact were in every way desirable as part of a ship's company. But the confinement was irksome to them. When they had served their time (many did not wait that long) they were paid off, with honorable discharges, medals and commendation; but what inducement had they for re-enlistment? Their commanding officer could only say, I will do what I can for you; he could not assure them of anything. He could not say to the boy, You have done so well on board or during your term of service, that I will see that you have an opportunity to compete for a warrant officer or even seaman gunner, because there is absolutely no standard laid down which would entitle them to compete for these honors. The commanding officer can recommend, and that is all, and perhaps never receive any notice of the communication.

I happened to serve on board of a ship, the major part of whose crew, about seventy, were apprentices enlisted when Rear-Admiral Shufeldt was Chief of the Bureau of Equipment and Recruiting. They had served about two years on board of a training ship. They were as fine a body of young men as one could wish to see; well developed, intelligent, and out of debt—bags full of clothes; they went at once to their stations, and that part of the ship's company was organized. They served on board this ship until reaching majority, about three years. They gave great satisfaction. On the expiration of their enlistments a few, I think four, were recommended by their commanding officer to be given facilities to become instructed at one of the navy yards in the duties of sailmaker, gunner and boatswain, that they might have an opportunity to become warrant officers. Nothing was done for them, and I very much doubt if there are any of this lot of seventy in the service to-day. How simple it would be for the Government to appoint annually, after a competitive examination, according to prescribed forms and upon specified subjects, a certain number of warrant officers from those who had served as apprentices, and stop making such appointments from outside of the navy. The law says preference shall be given to these men, and the whole machinery of the examination and appointment is under the control of the Department. It would be better if there was an act of Congress directing the Department to make a certain number of these appointments annually, appointees to be selected according to merit from all entitled to compete.

A board of officers could be assembled to draw up regulations, specifying, first, the requirements of those who will be allowed to compete for these positions; secondly, the character of the examination to be passed; and, thirdly, the facilities to be given to acquire the knowledge.

The law says, that to be entitled to such a warrant, the candidate must re-enlist for three years, within three months from the date of his discharge as an apprentice. My plan would be to first classify the apprentices according to the year in which their terms expire; for instance, the class of 1885 would be composed of those entitled to discharge during that year; then establish a standard which must be attained to entitle one to be a candidate. Then, having selected the candidates, let them be sent to navy yards, torpedo station, gunnery ship and experimental battery for instruction. They could work while being instructed, and thus the Government would have some return.

For boatswain, carpenter and sailmaker, two years would probably be enough to spend at the navy yard. For gunner, this time could be divided between the Washington navy yard, torpedo station and experimental battery. At the expiration of this time let them be examined competitively, those who pass the required examination to be arranged in order of merit, and the vacancies in the warrant officers filled thus with acting appointments. Those who fail to pass, or for whom there are no vacancies, to be returned to the service.

Such a course would introduce a reform in the navy much to be desired.

In this connection I may be permitted to give my views upon the necessity of having warrant officers on board our ships. Warrant officers are the connection between the commissioned officers and the crew; they are leading men. It might happen that among the crew sent to a ship there were none qualified for boatswain's mate, gunner's mate, carpenter's mate or sailmaker's mate; the presence of corresponding warrant officers would be invaluable in fitting out the ship, or in any emergency. It has been said that warrant officers, with all the vices of sailors, wish all the privileges of commissioned officers, and that they are not diligent in the performance of their duties. If commanding officers do their duty this would not be the case, and this state of affairs can easily be rectified.

There are now on the active list 45 boatswains, 39 gunners, 51 carpenters, 32 sailmakers. On the basis of thirty-five ships in commission, with sail as well as steam power, there should be 70 of each grade; one-half at sea at one time. If this number be gradually reached, say by ten appointments a year, the limit above would never be exceeded, and could not be reached in ten years. Then the waste would be sufficient to keep up a demand at this rate.

Firemen and Coal-Heavers.

Such apprentices as evince a desire to become firemen and show a skill in handling machinery, should be given an opportunity, on re-enlisting after attaining their majority, to be taught the duties of firemen. They could first be sent to the shops in our navy yards and taught to fire boilers on shore, the different parts of the boilers and engines, and their connection. After a year's experience they should be sent to steamers for instruction in their duties. The best vessels for this purpose would be those that are constantly under steam, such as dispatch and transport steamers and monitors. They should be well

paid, and receive an additional pay on each re-enlistment, and should be eligible to promotion to machinists, boilermakers and coppersmiths, and be given the preference for such positions. These men are of the most valuable and necessary on board ship, and their life when under steam is a laborious one and trying to the health.

Coal-heavers should be enlisted as now. Their duties are such as require robust men, and do not call for any great degree of intelligence.

Apprentices should not be required to serve as coal-heavers or firemen, except in cases of emergency, because this kind of work for growing lads would be very injurious to their health. The great heat to which they are exposed when on watch, and the great change in temperature to which they are exposed when off duty, are such that only men of very strong constitutions can stand them.

Seamen Gunners.

General orders Nos. 272 and 281 would be quite sufficient if they provided for instruction in torpedoes, such as charging, connecting and exploding them, and a course in practical electricity; and if they were carried out. Although both of these orders were issued in 1881, I feel quite safe in saying there is no gunnery ship in the service to-day, and that these orders have never been carried out. There are several steam sloops of war available for this purpose; one of these, with a tender sufficiently large to mount a couple of guns (like the Standish now in use at the Naval Academy), should be immediately commissioned, and the entire crew, exclusive of firemen, coal-heavers, marines and attendants, should be composed of re-enlisted apprentices, or those who may have a short time to serve and intend to compete for seaman gunners. An addition to the terms of the order should be that all petty officers should be appointed from seaman gunners, when they are available.

Permanent Petty Officers.

NAVY DEPARTMENT, WASHINGTON, *November* 21, 1884.

General Order No. 327.

From and after January 1, 1885, the form of honorable discharge from the naval service, authorized by Section 1427, Revised Statutes of the United States, will be the "Honorable Discharge and Continuous-Service Certificate."

All men (except officers' cooks, stewards and servants enlisted for special service) now serving under enlistments for three years, or who may hereafter enlist for that period, shall receive an "Honorable Discharge and Continuous-

Service Certificate" at the expiration of their terms of enlistment, upon the recommendation of their commanding officers.

Any man holding an "Honorable Discharge and Continuous-Service Certificate," who re-enlists for three years, within three months from the date of his last discharge, shall receive an increase of one dollar per month to the pay prescribed for the rating in which he serves, for each consecutive re-enlistment, in addition to the "honorable discharge money."

Any man holding an "Honorable Discharge and Continuous-Service Certificate," who fails to re-enlist within three months from date of last discharge, will derive no further advantages therefrom.

The Department directs that the records of conduct and professional qualifications on the "Enlistment Records" shall be a verification of the recommendations for "Honorable Discharge and Continuous-Service Certificate," and hereafter only those shall be recommended who obtain, during their terms of enlistment, a general average of four.

In order that commanding officers of vessels upon which men complete their terms of enlistment shall be informed as to the previous merit of said men, the original "Enlistment Record" (Form 12), which accompanies an enlisted man upon his first transfer, will hereafter be carefully preserved and accompany him upon all subsequent transfers, until his term of enlistment has been completed. This form has been amended so as to show the record of conduct as averaged by the commanding officer of the vessel for the period for which the man has served under his command. The final averages will be made by the officer under whom the man is serving at the time his enlistment expires, when about to be discharged. These "Enlistment Records" must be forwarded to the Bureau of Equipment and Recruiting.

In addition to the above requirements, enlisted men must serve at least two years and nine months of their terms of enlistment in order to receive an "Honorable Discharge and Continuous-Service Certificate," except in extraordinary cases, which will be provided for by the Department as they may occur.

When any man holding an "Honorable Discharge and Continuous-Service Certificate" shall fail to receive a recommendation for its renewal upon the expiration of his term of enlistment, the words "not entitled to Honorable Discharge" shall be written on the line below the last entry. Men so discharged will receive no further pecuniary benefit from their "Honorable Discharge and Continuous-Service Certificate," and entries of a re-enlistment or subsequent service must not be noted thereon.

"Good-Conduct Badges" are special distinctions for fidelity, zeal and obedience, and will not be granted for the first term of enlistment under "Continuous Service." At the expiration of subsequent re-enlistments for three years, within three months from date of discharge, men who hold "Honorable Discharges and Continuous-Service Certificates," have obtained a general average of four and five-tenths (4.5) on their "Conduct Records," and are recommended by their commanding officers, will be entitled to and receive said badges. The first badge will be a medal, as hitherto. Subsequent badges to

be clasps, with the name of the vessel from which given engraved thereon, to be worn on ribbon above medal. When any enlisted man shall have received three such badges, under consecutive re-enlistments as above, he shall be enlisted as a petty officer in the rating in which he is best qualified to serve, and shall continue to hold a petty officer's rating during subsequent continuous re-enlistments, and shall not be reduced to a lower rating except by sentence of Court-Martial.

Paragraphs 18 and 20, page 100, and paragraph 22, page 101, U. S. Navy Regulations, are hereby annulled.

William E. Chandler,
Secretary of the Navy.

The above General Order is very good so far as it goes. In my opinion, it should go further. It should prescribe the requirements of every grade of petty officer, and none should be appointed that could not attain the standard. In addition, any petty officer who was discharged as such, at the expiration of any enlistment, should have a preference for the same billet on a re-enlistment. Permanent petty officers should hold such appointments from the Secretary of the Navy or Chief of the Bureau of Equipment and Recruiting, in the same manner that non-commissioned officers of the Marine Corps hold their appointments from the Colonel Commandant.

I know of no particular rule or regulation setting forth the requirements of petty officers; in consequence, a petty officer in one ship may have quite a different standard to reach than the same rate in another ship. This should be rectified and a uniform standard adopted for each rate.

Commutation in Reducing Enlistment by Good Behavior.

Seamen are enlisted for three years. I would propose, that for every year of good behavior one month be taken off; so that a three years' enlistment might be reduced three months, and in twenty-one years' enlistment it would only make that many months. This gratuity, in my opinion, would be a great inducement to good men to remain in the service, besides being a substantial reward for good behavior. The comfort of every one on board ship is so much enhanced by the good conduct of the crew that every reasonable inducement should be given to attain this desired end. While I do not wish for a moment to name penitentiaries and men-of-war in the same category, still there is one similar element, that of restraint. Now, in all prisons this commutation is in vogue, with most bene-

ficial results. It is the hope, the ray of light, to the forlorn convict, and makes him obedient when punishment had failed to do so. The loss to the Government would be nothing compared with the gain of having good men in the service.

Honorable Discharges, Continuous-Service Certificates, Medals, and Bounty for Re-enlistment.

Under this head, honorable discharges and bounty for re-enlistment are provided for by law, as heretofore quoted. It would be much better if the law covered all. An honorable discharge must be given to those who deserve it as a testimonial of fidelity and obedience, upon the recommendation of the commanding officer.

The question of what is meant by fidelity and obedience is very puzzling. One commanding officer may, and does, say, for example, that drunkenness on shore should not interfere with this discharge, while another has the contrary opinion; so that a drunkard from one ship will get such a discharge and the same man from another would not. Again, the law is silent as to his professional qualifications, so that as long as a man behaves himself, even though he be dull and stupid, he is entitled to this reward.

The continuous-service certificate which, unfortunately, is only regulation, and liable to be discontinued, or altered for better or worse, is faulty, in that marks therein given are given by the commanding officer when a transfer or discharge is made, and need not be from any record that may have been kept. The officer of division should be required to mark the men of his division at least monthly. These marks, if approved, should be published to the crew, and the average of them should be given in case of transfer or discharge. In conduct, the mark should be given by the executive officer. This would warn a man who was behindhand to improve, and would show those who did well that their efforts were appreciated. Besides, it would give all concerned an opportunity to appeal and have any errors corrected. Let the crew see they are being dealt with fairly and openly, and I feel sure it will be a great inducement for them to remain in the service.

Outfit on each Re-enlistment.

Soldiers and marines receive not only an outfit on enlisting, but a yearly allowance of clothing. Why should seamen not have the

same? Surely they are as much entitled to it as the marine who serves with them. The seaman should be given it as an act of justice to him. It has been estimated that this outfit will cost about fifty dollars ($50). At present, a man who enlists in the navy is at once this much in debt to the Government, and by regulation, a seaman in debt cannot have leave or liberty. Fifty dollars represents about three months' pay, so for that time the man is a prisoner, which is certainly not right or fair. If it is not deemed advisable to give this outright, it might be charged against the recruit at the rate of two ($2) dollars per month till all is paid. If the man deserted, the Government would lose its balance. I believe that many of the desertions now are the result of this confinement on board while getting out of debt. It certainly gives much dissatisfaction. I firmly believe that the granting of this outfit will be a great inducement to seamen to remain in the service.

Government Savings Bank.

In our army the soldiers are given four per cent. for their savings. An Act of Congress was passed for this purpose in 1872. Section 1305, Revised Statutes, is as follows: "Any enlisted man of the army may deposit his savings, in sums not less than five dollars, with any Army Paymaster, who shall furnish him a deposit book, in which shall be entered the name of the paymaster and of the soldier, and the amount, date and place of such deposit. The money so deposited shall be accounted for in the same manner as other public funds, and shall pass to the credit of the appropriation for the pay of the army, and shall not be subject to forfeiture by sentence of court-martial, but shall be forfeited for desertion, and shall not be permitted to be paid until final payment on discharge, or to the heirs or representative of a deceased soldier, and that such deposit be exempt from liability for such soldier's debts. Provided, that the Government shall be liable for the amount deposited to the person so depositing the same."

Section 1306. "For any sum not less than fifty dollars so deposited for the period of six months, or longer, the soldier on his final discharge shall be paid interest at the rate of four per centum per annum."

Section 1307. "The system of deposits herein established shall be carried into execution under such regulations as may be established by the Secretary of War."

"The Secretary of War commends this system of banking in the highest terms, and states that it has been the means in a marked

degree of decreasing desertion, and thereby increasing the tone and morale of the army. The system is also in operation in the British Navy with like gratifying results."

A seaman has no opportunity to invest his savings during the period of his enlistment. Frequently on a foreign station, he could not invest if he would. The consequence is, as a rule, he squanders his hard-earned wages in riotous living, when he gets an opportunity on shore. It would be a simple matter at the end of every quarter for a seaman to deposit with the paymaster his savings. The paymaster could enter the amount in a column for the purpose in the quarterly returns, and add the interest every quarter. At the expiration of the term of enlistment the man could be paid principal and interest, or if he desired to re-enlist, his savings might be transferred to his new account on re-entering. By so doing, a man after twenty-one years service might have enough laid by to make his old age reputable and comfortable. A great fault with sailors is their reckless extravagance. Such a Savings Bank system would tend in a great degree to cure this evil. A matter so simple, and which has elsewhere been tried with such good results, certainly should have a trial in our navy.

Uniformity of Privileges and Punishments.

I have already given the system of rewards to, privileges of, and grading of a ship's company as now authorized in the navy. There can be no question but that this has been an immense benefit to the service and reflects great credit upon its originators. Unfortunately, it is simply regulation, not law, and may be changed at any time for the worse, as well as for the better, and even as regulation it is not fully carried out.

The defects of this system are, that while a high standard is required for the first grade, so high as to be barely attainable, the arrangement of the other grades or the qualifications for them are left to the commanding officer. This latter defect is a very serious one, and confirms the old yarn of "different ships, different rules." Instead of a sailor being justified by saying that in the last ship such rules were observed and he expected the same to hold in his present ship, he finds to the contrary; and that whatever he may have been taught as proper in the last ship does not of necessity mean the same now. Much discontent arises from this. A board of competent officers should be appointed to devise a uniform system of rewards and indulgences, and a uniform system of qualifications for the various

conduct grades. These, after the approval of the Secretary of the Navy, should become law.

The Navy Regulations of 1876 described the punishments that a commanding officer might inflict, and suggested a list of offences and punishments therefor, as follows:

PUNISHMENTS.

For the purpose of promoting good order and discipline in the Navy, and to secure uniformity in awarding punishments, the following schedule of offences, with proportionate and appropriate punishments, will be adopted in all vessels of the Navy as applicable for infliction by Commanding Officers of vessels, without resort to summary or to general courts-martial:

A. Solitary confinement, 5 days or less; no irons; bread and water.
B. Solitary confinement, 3 days or less; no irons; bread and water.
C. Solitary confinement, 7 days or less; no irons; full rations.
D. Solitary confinement, 5 days or less; no irons; full rations.
E. Solitary confinement, 3 days or less; no irons; full rations.
F. Confinement, 10 days or less; double irons; full rations.
G. Confinement, 5 days or less; double irons; full rations.
H. Confinement, 3 days or less; double irons; full rations.
I. Confinement, 10 days or less; single irons or without irons; full rations.
J. Confinement, 5 days or less; single irons or without irons; full rations.
K. Confinement, 3 days or less; single irons or without irons; full rations.
L. Confinement, overnight; single irons or without irons; full rations.
M. Reduction of any rating established by himself.
N. Deprivation of liberty on shore.
O. Extra duties.

List of offences suggestive of such as may be punished by order of Commanding Officers of vessels:

No. 1.	Absence without leave	N
No. 2.	Leaving boat or working-party	N
No. 3.	Making false charges against any of the crew, if made by Petty Officer or other person rated by Commander	M
No. 4.	If by Petty Officer, or other person not rated by Commander	O
No. 5.	Lying	O
No. 6.	Answering for another man at watch-muster, at quarters, or in a boat	O
No. 7.	Being habitually dirty or slovenly. (As a reformatory measure in such cases, besides the punishment, frequent inspections of the person and clothing by Officer of Division or Deck, or by Master-at-Arms or Ship's Corporal, should be made until the habit is reformed. The Marine Officer or Non-commissioned Officer of Marines shall make these inspections with the marines)	O

No. 8. Not being in proper uniform (frequent inspections also)....	O
No. 9. Neglecting to carry out orders........	O
No. 10. Disobedience of orders........................	A to L
No. 11. Drunk at sea or on duty...	M or O
No. 12. Returning from leave drunk......................................	none
No. 13. Occasionally drunk...	M or O
Confinement until sober, as a precautionary measure, in these cases.	
No. 14. Smuggling liquor...	A
No. 15. Trafficking in liquor..	A
No. 16. Neglect of ordinary duty, or negligently performing it.......	M or O
No. 17. Not answering muster at watch or quarters.....................	M or O
No. 18. Malingering	M or O
No. 19. Inattention to duty (frequent inspections also)..................	M or O
No. 20. Gambling	A, M, or O
No. 21. Misbehavior at Divine service...........................	A, M, or O
No. 22. Making noise on deck, aloft, or at quarters........................	A to L
No. 23. Spitting on deck, either below or from aloft.....................	O
No. 24. Sleeping in tops or in boats, whether top or boat keeper or not..	O
No. 25. Getting in or out of ports..	O
No. 26. Throwing things overboard from improper places............	O
No. 27. Not making or not having clothes or hats made in time.....	O
No. 28. Carelessness about clothes-bag, or going to it without permission..	O O
No. 29. Leaving clothes about...	O
No. 30. Hanging hammocks or clothes in improper places............	O
No. 31. Washing hammocks or clothes in improper places............	O
No. 32. Washing hammocks or clothes badly or at improper times.	O
No. 33. Lashing hammocks badly (frequent inspections also)...... ...	O
No. 34. Untidiness as to hammock or bag (frequent inspections also)..	O
No. 35. Cursing others, or using obscene language.........................	A or B
No. 36. Striking inferiors or equals..	A or B
No. 37. Fighting	A or B
No. 38. Quarreling with words or using provoking language.........	F to L
No. 39. Smoking out of hours or in improper places.....................	F to L
No. 40. Having lights after hours........	F to L
No. 41. Negligently letting fall or lowering anything from aloft.....	O
No. 42. Using knife or marline-spike aloft without good lanyard...	O
No. 43. Carelessness with respect to arms (frequent inspection)....	O
No. 44. Not keeping arms clean (frequent inspection)...................	O

In all cases in which extra duty is imposed as a punishment it should be as nearly as possible of the kind of duty that has been neglected, if awarded for neglect of duty; and, if awarded for other offences, it shall be of such nature as will most tend to correct them and prevent their repetition.

Aggravated cases in the preceding list of offences can, of course, be referred to summary courts-martial, or to general courts-martial, at the discretion of Commanders of vessels, to whom alone the law confides the power to inflict punishment, or to cause it to be inflicted, on board vessels of the Navy, by the exercise of their own authority.

If these had the authority of law, or were mandatory instead of suggestive, they might have been beneficial to the service, but in their present yielding form they are virtually void. The navy is not to be governed by suggestions, but by commands. I do not mean to be understood as approving this code, on the contrary I think it very faulty, but had it the force of law one could be reconciled to it.

In my opinion the punishments, in most cases, are disproportioned to the offences. For example, absence without leave, and leaving a boat or working party, offences nearly akin to desertion, are punished only by deprivation of leave on shore, and it may happen there is no opportunity to give leave. So also making false charges, lying, being dirty and slovenly, being drunk, spitting on decks, are punished alike by extra duties. While smoking out of hours, or in improper places, by confinement in irons, single or double, not exceeding ten days.

With all due respect, I must say that nothing could be more absurd or more unjust. Can it be possible that it is a more serious matter to smoke out of hours than to lie, to get drunk and therefore be unfit for duty? Surely a system of morals founded upon such ideas would ruin any community, and why not a man-of-war? Again, making a noise on deck, aloft, or at quarters is to be punished by confinement, solitary, on bread and water for five days or less, or confinement with or without irons for ten days or less. If such regulations were read over to thinking men they would never enlist unless driven to do so by desperate circumstances. Would any man enlist were he told that if he made a noise on board ship he would be imprisoned on bread and water, or in irons? I admit that noise is detrimental to a successful drill or exercise, but I cannot say or believe that it is criminal, or that it is more immoral than to deceive, to lie, or to get drunk, or so great a breach of discipline.

I do not believe this code is strictly carried out on any vessel of war now in commission. It should be revised by a Board of Officers, and, if then approved, become law. There should be an absolute uniformity in punishments for offences, as the privileges and rewards are so dependent upon them. There are many officers in the navy

who look upon drunkenness as natural to a sailor, and therefore should not be severely dealt with. Indeed, I have heard some say that they never knew a good seaman who was not a drunkard. There are others who look upon this as one of the worst crimes, and think no punishment too severe. And so with many other misdemeanors. Yet these commanders are both sincere in their convictions. With such a state of affairs is it to be wondered that so few good men, trained seamen, re-enlist? Manifestly, then, one great inducement would be a uniform system of rewards and punishments. It would be better to have a law enacted; but in the absence of a law, a peremptory regulation established by the Secretary of the Navy could be drawn up to remedy these defects.

Pensions for Disability, Occurring in Line of Duty.

If the law were amended so that these pensions should be graded according to the rate held by the seaman at the time his disability occurred—the present law places the best man on the same footing with the poorest—it would be a desirable improvement.

Pensions to Widows.

The sections of the Revised Statutes already quoted place the highest pension to a widow at eight ($8) dollars. No amount of good service of the husband can make it more. No matter if he is a first-class petty officer or an ordinary seaman, his widow's pension is the same. This should, in justice, be changed, so that the widows may receive pensions according to the rate held by, and the merits of, their deceased husbands. It seems to me that a board of officers might devise an equitable scheme which, no doubt, would receive the approval of Congress and the President. Let a man see that merit will be considered and he will not only be more contented, but will strive to be meritorious.

Rewards for Long and Faithful Service.

Pensions for twenty-one years Service after Majority.

Every seaman who serves twenty-one years continuously, as such, after reaching the age of twenty-one, should receive a pension according to his merits.

(1) First-class Petty Officers entitled to be enlisted as such, and

who have complete good-conduct badges and honorable discharges, one ($1.00) dollar per day.

(2) First-class Petty Officers, entitled to be enlisted as such and who have not less than half the good-conduct badges, and all the honorable discharges, and all other Petty Officers who are entitled to be enlisted as such, and who hold complete good-conduct badges and honorable discharges, seventy-five (75c.) cents per day.

(3) Other Petty Officers, who are honorably discharged on the completion of twenty-one years continuous service, after majority, and seamen who are honorably discharged after this service, fifty (50c.) cents a day.

The age of an apprentice, sixteen, which is as old as one can enter, would, with his service as apprentice, five years, and twenty-one years after, make twenty-six years of continuous service to the United States. These are the best years of his life. During this quarter of a century of service he will have had no opportunities to make friends on shore, or to seize any opportunity to make a living outside of the navy. He will be forty-two years of age, and will be much broken by his service afloat. It will be some time before he can find something to do to help to support him. He will naturally want to marry and have a home; unless he has this help from the Government he will not be able to do so. I do not think it at all unreasonable after a quarter of a century's service at sea, away from home, on a small pay, that the Government should be asked to pay these moderate pensions. Besides, the standard is high, that it seems very little to give for so much worth, so much value received.

Can it be doubted that this will be a greater inducement than anything else? When a man realizes that he can be provided for life, will he not strive to do well, and will not more remain in the service than do now? At present the seaman has little opportunity to better himself in the navy, no way of providing for his old age except to go to an asylum, so he very naturally leaves and tries something else. He tries the merchant service, where he can get to be an officer. He tries steamboating or yachting, which pay better, in which he has a more comfortable time, and which give prospects of advancement. Or he tries a shore life. Men of spirit, intelligence and ambition are what we want in the navy; they are a necessity. The honor of the flag is entrusted to them. But such men are not to be had without paying for them. England gives similar pensions, but at an earlier age, at the age of thirty-eight (38).

The scheme works well there, and I believe this proposed, though not so liberal as theirs, will give good results in our navy. The minor details would have to be considered by a board, but the essential points would be as I have given under the headings (1), (2), (3).

The cost of this plan would not be great. Suppose that an average of one hundred (100) men receive this benefit annually, at an average of seventy-five (75) cents per day; in one year this would amount to about $27,000; in twenty-one years, at this rate, to about $500,000; but the tables of life insurance companies their death rates would show that of 100 men who reach forty-two years of age, not more than one-half would reach sixty-two (62), or be benefited twenty-one years. So to commence, the sum required would be small, and at the end of thirty years from now about $300,000 would be required, which would probably be the maximum.

I venture to say, that if a million dollars of the prize fund were set aside for this, and the interest, when not required, be allowed to accumulate, and be again put on interest, it would suffice to meet the expense. No one could be benefited for years to come, because the present training system has not been in force twenty years, and very few apprentices have re-enlisted under continuous service certificates.

Employment in Life-Saving Service after Discharge from the Navy. Preference for Employment on Board of Receiving Ships, at Navy Yards and Stations.

The right to have such employment can hardly be disputed. That the men would be well suited and qualified for the duties is unquestionable also. If, then, when the trained seamen received their discharges, would register their names to be so employed, and be notified when vacancies occur, I think good men would be secured with very little trouble. And a sailor would see another inducement to remain in the service the required time and perform his duties well.

It is very desirable that the cooking of the ration for the men on board ship should be improved, and many consider that with a little better dietary men would be induced to remain. I think the ship's cooks should be trained for their duties. This has been frequently recommended, and it is difficult to see why nothing has been done. It could readily be managed on board the receiving ships. The navy

ration is the best in the world; let it be well prepared and there will be no cause for complaint.

I have heard men say that they were always glad to get away from the receiving ships because they were uncomfortable and not well treated. According to their representations, they seem to have been regarded, while on receiving ships, as purely objects of prey. If these complaints are true, then it would be an inducement for men to remain in the service to have changes and reforms in the manner of conducting the affairs of these vessels.

The question how to employ men at this stage of their enlistment is a difficult one, for several reasons:

(1.) The ships are usually moored head and stern, and in ports where it would be impossible to fire shots from their guns; and their guns are antiquated, so that to drill the men at the guns is of no practical use.

(2.) The sails are unbent, and as a rule but few spars aloft, so no exercise of the sails or spars is practicable.

(3.) To drill with small arms, howitzers or swords is generally not practicable on board, and as (I believe) only one receiving ship is moored alongside a wharf, it is not convenient to send them on shore for this purpose.

(4.) Even were it possible to do all these things, there are generally so few officers attached to the ships that it would not be practicable. I would remedy this by having enough officers on duty. Then all receiving ships should be moored alongside the navy yards, and a suitable drill and play ground be provided near them. Under the present regime recruits cannot be given liberty. If they had grounds where they could play ball, pitch quoits, and other games, they would be more contented. Besides, there should be reading rooms and what would correspond to a canteen in the army. A small monthly subscription from the seamen would pay for the papers and periodicals, and the canteen no doubt would be self-supporting. If the canteen were abused, punish the offenders and the abuses would soon correct themselves. Make the receiving ships desirable homes for the seamen, and they will not hesitate to re-enlist because of the fear of being uncomfortable and uncared for while awaiting transfer to a sea-going vessel. The customs, privileges, duties and punishments should be alike on all these ships.

force and direction of the wind, are subject to the errors of estimation or of observation in any case; and the estimations or observations having been made, the tables, if easy of application, furnish on the one hand a quick and approximately accurate solution of what is largely attempted by guesswork on the other hand.

It is claimed also that by practice officers can soon become very expert in the use of tables to apply corrections, and the time thus expended cannot in these days be used to greater advantage if it will lead to any improvement in gunnery practice.

The mathematical work necessary to show on what foundation the formulae used in the construction of the tables rest, is here given; but it is not at all necessary to a proper understanding of their construction and use.

It must not be supposed that the formulae as finally reached furnish a rigid solution of the problems, but they give a close approximation to the truth, and will suffice for nearly all cases which are likely to happen in firing guns at sea.

Let us now consider in detail the three causes before mentioned.

The Influence of the Wind.

The method followed is that of M. Hélie, Professeur a l'École d'Artillerie de la Marine, in a pamphlet on this subject published in 1874, somewhat abridged.

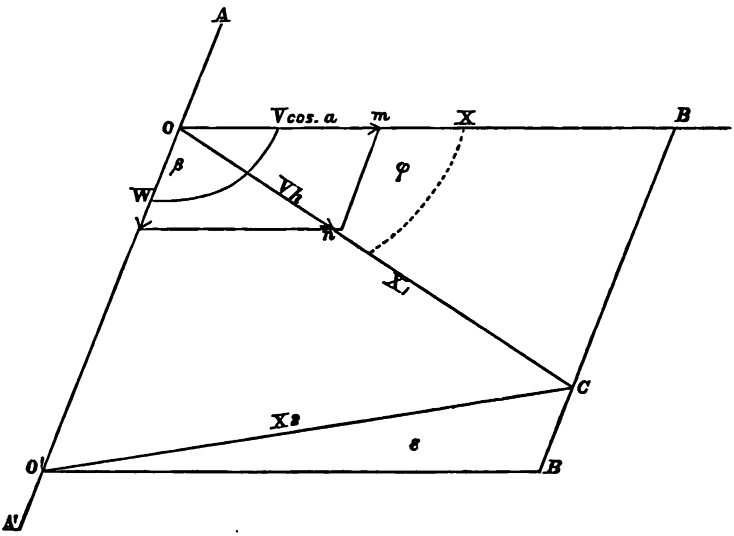


Fig. 1.

Let Fig. 1 represent the horizontal plane passing through the point O.

OB direction of line of fire.

B point of fall of the projectile when the gun is fired in a calm atmosphere and at an angle of elevation α, the gun being at O.

AA' direction of the wind with respect to the line of fire.

$V\cos\alpha$ horizontal component of the initial velocity V.

W velocity of the wind.

Didion in his Traité de Balistique shows that if we suppose the whole system—gun, projectile, atmosphere, etc.—to have a horizontal motion equal to and opposite to that of the wind, that is to say, if in the figure the wind is from $A'O$, if we suppose the whole system to have motion equal to that of the wind and in an opposite sense, the absolute velocity of the wind reduces to zero, and, so far as the relative positions of the parts of the system are concerned, we would have the condition of a calm atmosphere. On this hypothesis we suppose the system to have at the instant of firing a velocity equal to W and toward A' from O, then the projectile on leaving the gun has a resultant velocity of which the horizontal component is V_h, the direction of which is the resultant of $V\cos\alpha$ and W.

At the end of a given time T the projectile will fall at some point C, but the points O and B at the end of the same time have, owing to the motion given to the system, moved to the new positions O' and B', the line OB' parallel to OB, and the relative positions of the gun, point of fall and line of fire will be represented by the triangle $O'CB'$.

The time T, when a very close approximation is desired or when the angle of elevation is large, should be found from a formula in which $T = F(V_1, \alpha_1)$, in which V_1 is the resultant initial velocity. The movement of the system has not changed the vertical component of the initial velocity V and is always $V\sin\alpha$, hence these quantities may be found from the formula $V_1^2 = V^2\sin^2\alpha + V_h^2$, and

$$\tan\alpha = \frac{V\sin\alpha}{V_h}.$$

In addition the range X_1 corresponding to (V_1, α_1) should be found.

However, for the purpose of correcting firing at sea, at angles of elevation of 5° and less, which with the new guns will include ranges to at least 4000 yds. and with the 8-in. Converted Rifle to 2800 yds., distances within which naval actions will probably be fought, the

error made by taking T and X as the time of flight and range respectively corresponding to the initial velocity V and elevation α will be very small and may be neglected. On this hypothesis we have, returning to the triangle $O'CB'$,

$$B'C = BB' - BC = WT - W\frac{X}{V\cos\alpha}$$

because $\dfrac{BC}{W} = \dfrac{X}{V\cos\alpha}$ from the similar triangles Omn and OBC.

Now

$$\frac{\sin\epsilon}{\sin\beta} = \frac{CB'}{O'C} = \frac{WT - W\dfrac{X}{V\cos\alpha}}{O'C}\,,$$

or

$$X_2 \sin\epsilon = \left(T - \frac{X}{V\cos\alpha}\right) W\sin\beta.$$

Evidently $X_2 \sin\epsilon$ is the lateral deviation of the point C from the line of fire $O'B'$; and since ϵ is a very small angle, its sine is sensibly equal to the tangent, and we have

$$\text{deviation} = d = \left(T - \frac{X}{V\cos\alpha}\right) W\sin\beta, \qquad (1)$$

which is the formula given in Brēger, "Probability of hitting an object of any form," translation by Lieutenant C. A. Stone, U. S. N., page 50.

From the triangle OCO' we have

$$X_2 = X_1^2 + W^2T^2 - 2X_1 WT\cos(\beta - \varphi).$$

In this equation the term W^2T^2 is so small when compared with X_1^2 that it may be neglected or multiplied by a quantity less than unity, $\cos^2(\beta-\varphi)$, say, and the expression becomes a perfect square; we have then,

$$X_2 = X_1 - TW\cos(\beta - \varphi),$$

and since φ is always a very small angle and becomes inappreciable when β is small, we can without great error write $\cos\beta$ for $\cos(\beta-\varphi)$, and the formula becomes

$$X_2 = X_1 - WT\cos\beta.$$

The time T and X_1 correspond, as has been before explained, to the initial velocity V_1 and the angle of elevation α_1, but for the purpose of approximations affecting firing at sea, within the limits before mentioned, we may use T and X corresponding to V and α, and we have finally

$$X_2 = X - WT\cos\beta.$$

The angle β is considered as a positive angle, and is reckoned from the target on either side of the line of fire around to the rear of the gun.

From (1) and (2) we see that the sign of d is always positive, and that the sign of the second term of the second member of (2) is negative for values of β between 0° and 90° and positive for values between 90° and 180°.

Colonel Maitland, R. A., gives a method for finding the lateral deviation due to the wind, less simple in form than the preceding, as follows, the wind being considered as a constant force blowing across the range, and acting uniformly on the projectile. His method can be used if considered desirable.

Let $p =$ pressure of wind in pounds per square foot.

$A =$ area of longitudinal section of projectile in square feet.

From the computed results of many practice tables he concludes that the expression pA represents with practical accuracy the pressure on the projectile tending to move it from the direction of the line of sight.

Sir Henry James gives the following ratio of pressure to velocity of the wind:

$$p = .005\,V^2 \text{ in miles per hour,}$$
$$\text{or } p = .00232438\,V^2 \text{ in feet per second.}$$

Now if this is a uniform pressure, and if the wind makes an angle D with the line of fire, the path of the projectile will resemble a parabola, and for heavy shot and short ranges or light winds the formula is:

$$d = \text{deviation in feet} = \frac{p \sin DAgt^2}{2\omega}$$

ω being the weight of the projectile.

His formula may be obtained as follows: Let $M =$ mass of the projectile, and $f =$ accelerating force acting on the projectile, then

$$Mf = p \sin DA.$$

or
$$f = \frac{pAg \sin D}{W} = \frac{dv}{dt}$$

integrating
$$V = \frac{pAg \sin Dt}{W} + C,$$

when $t = 0$, $V = 0$ $\therefore$ $C = 0$

$$V = \frac{ds}{dt} = \frac{pAg \sin Dt}{w},$$

integrating
$$S = \frac{p \sin DAgt^2}{2w} + C'$$

when $t = 0$, $S = 0 \therefore C' = 0$

hence
$$S = d = \frac{p \sin DAgt^2}{2w}.$$

This equation is not accurate enough for light shot and high winds, since a light shot takes up a sideways velocity due to the wind more easily than a heavy one, and ultimately the shot will have the same velocity in that direction as the wind.

It is clear then, that the pressure of the wind on the side of the shot at any instant is that due to the difference between the sideways velocity of the latter and the velocity across the range of the former.

Colonel Maitland thus treats this case: putting V as the sideways velocity of the projectile communicated to it by the wind, we have $W \sin D - V$ as the difference before mentioned, and hence to find the pressure we have

$$p = .00232438\,(W \sin D - V)^2,$$

from the preceding we have

$$f = \frac{dv}{dt} = \frac{pAg}{w} = \frac{.00232438Ag}{\omega}\,(W \sin D - V)^2$$

$= a\,(W \sin D - V)^2$, when a is a constant for each nature of projectile.

$$\frac{dt}{dv} = \frac{1}{a}\left(\frac{1}{(W \sin D - V)^2}\right);$$

integrating
$$t = \frac{1}{a} \cdot \frac{1}{W \sin D - V} + C$$

when $t = 0$, $V = 0 \therefore C = -\frac{1}{a W \sin D}$.

Solve for V, we have,

$$V = W \sin D - \frac{W \sin D}{at W \sin D + 1} = \frac{ds}{dt}$$

integrating, we obtain

$$S = W \sin Dt - \frac{1}{a} \cdot \log_e (at W \sin D + 1) + C'$$

when $t = 0$, $S = 0 \therefore C' = 0$.

Substituting the value of a, we have for deviation in feet,

$$d = W \sin Dt \,\frac{\omega}{.00232438Ag} \cdot \log_e\left(\frac{.00232438Ag\, W \sin Dt}{\omega} + 1\right).$$

In this formula the first term gives the distance passed over by the wind in the time t, and the second term the space lagged behind by the projectile in that time, and the difference is evidently the sideways travel of the shot.

This last remark applies to the formula deduced after Prof. Hélie's method.

In log-books kept at sea, a table of the force of the wind, pressure in pounds per square foot, corresponding to different velocities of the wind in miles per hour, is given, as follows. The velocity of the wind is measured by an anemometer. It will be found that the pressure agrees very closely with results deduced from Sir Henry James' formula.

Nautical Scale.	Force of the Wind.	Pressure in Pounds per Square Foot.	Velocity of the Wind. Miles per Hour.
0	Calm........................		
1	Light Airs.	0.004 to 0.019	1 to 2
2	Light Breezes........................	0.08	4
3	Gentle Breezes........................	0.4	9
4	Moderate Breezes........................	1.0	14
5	Stiff Breeze........................	1.5	17
6	Fresh Breeze........................	2.0	20
7	Very Fresh Breeze........................	3.0	24
8	Moderate Gale........................	5.0	30
9	Strong Gale........................	8.0	40
10	Very Strong Gale........................	23.0	67
etc.	Etc........................	etc.	etc.

The Motion of the Gun.

In this case the projectile as it leaves the gun is supposed to have a velocity equal to and in the direction of the motion of the gun itself. Now if we can consider the motion in this direction as practically unresisted by the air, an approximate solution is very easily reached.

Professor Rankine gives a formula for the resistance in pounds to bodies moving in a fluid as follows:

$$R = k\rho A \frac{V^2}{2g}, \tag{1}$$

in which

$k =$ constant determined by empirical formulae or by experiment.
$\rho =$ weight of unit volume of fluid.
$A =$ area of cross section perpendicular to axis of motion.
$V =$ velocity of moving body.

Duchemin gives for a cylinder moving sideways — $k = .77$.

Then if $R =$ resistance in pounds,
$f =$ acceleration or $-f =$ retardation,
$M =$ mass of moving body,

we have $-Mf = R$, and from (1) we have

$$f = -\frac{k\rho A V^2}{2\omega},$$

ω being the weight of the moving body.

To show what the effect would be on an eight-inch projectile $2\frac{1}{2}$ calibres long, $W = 180$ lbs., moving sideways in air with a velocity of 15 f. s. or about 10 miles an hour, we have, taking the weight of a cubic foot of air $= .080728$ pounds, and since the area of the longitudinal section is about 1 sq. ft.

$$f = -\frac{.77 \times .080728 \times 1 \times 225}{2 \times 180} = -.03885,$$

hence the retardation is 0.3885 f. s. $= \frac{dv}{dt}$, whence it may be shown that

$$V = \frac{ds}{dt} = .03885t$$

and

$$S = \frac{.03885t^2}{2}.$$

At a range of 2800 yards, initial velocity 1450 f. s., the time of flight is $7^s.11 \therefore t^2 = 50.55$ and $S = .98$ foot nearly; for 20 miles an hour, $S = 4 \times .98 = 3.92$ ft. as the approximate errors made at the respective velocities.

The distance actually travelled, taking the resistance of the air into account, being 105.67 and 210.32 feet as compared with 106.65 and 214.30 feet, which would be the distance travelled on the supposition that the motion is unresisted and uniform; the difference is very small, and the resistance of the air for such low velocities may in practice be neglected in the case we are now considering.

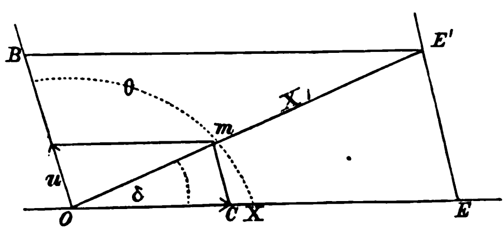


FIG. 2.

On the above hypothesis consider Fig. 2 as the horizontal plane through the point O at which the gun is situated. Suppose the gun

to be moving toward B with a velocity U, and if OE is the line of fire, E being the point of fall of the projectile with an initial velocity V and angle of elevation α when the gun is stationary. And if X is the range and T the time of flight corresponding to these data, and if the projectile during the time T has a uniform velocity in the direction of OB equal to U, then at the end of the time T it will fall at E'; EE' being equal and parallel to $OB = UT$.

The time T and range X can be found from formulae in which they occur as functions of V. α, or may be taken from range tables.

For ranges, then, at angles of elevation less than 5° we may with close approximation take T for a range X that would be given for an initial velocity V and angle of elevation α.

Thus approximating, we have from the triangle $BE'O$, the line $BE' = X$.

$$X_1^2 = X_2^2 + U^2T^2 + 2UTX \cos \theta.$$

But U^2T^2 is very small when compared with X_2^2 and may be neglected or multiplied by a quantity less than unity, $\cos^2\theta$, say, and we have

$$X_1 = X + UT \cos \theta. \tag{3}$$

From the similar triangles OCm and OEE' we have

$$\frac{\sin \delta}{\sin(\theta - \delta)} = \frac{U}{V \cos \alpha} = \frac{UT}{X}$$

or $X \sin \delta = UT \sin(\theta - \delta)$.

Since δ is always a very small angle and vanishes when $\theta = 0$, we may write $\sin \theta$ for $\sin(\theta - \delta)$. Again the sine and tangent of δ are sensibly equal, and if the lateral deviation is $X \tan \delta$, we have

$$d = UT \sin \theta \tag{4}$$

From formulas (3) and (4) we see that the sign of the second term of the second member of (3) is positive for values of θ between 0° and 90° and negative for values between 90° and 180°; θ being taken as a positive angle and reckoned from the line of fire on either side around to the rear of the gun. d is always positive.

The Motion of the Target.

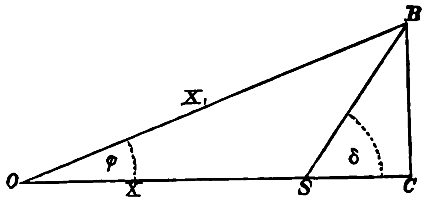


Fig. 3.

Let Fig. 3 be the horizontal plane through OaS.

If the target is at S, Fig. 3, and moving with a velocity U toward B, the line SB making an angle δ with the line of fire OS, the gun being fixed at O. At the end of the time T (T being the time for a shot to travel the range X or OS), the target will have arrived at some point E and $BS = UT$.

Now the gun must be so aimed that the shot will fall at B at the moment the target arrives at that point, hence the sight-bar must be set for a range X_1 and the sliding leaf to allow for a lateral deviation BC at the range X_1. We have $BC = UT \sin \delta$ and $Sc = UT \cos \delta$, and since φ is always a small angle we have approximately

$$X_1 = X + UT \cos \delta \qquad (5)$$
$$d = UT \sin \delta \qquad (6)$$

If d' is the lateral deviation for the range X it will be found practically to differ but little from d, and may be used in its stead.

d is always positive, and the second term of the second member of (5) is positive for values of S between 0° and 90°, and negative for values between 90° and 180°, δ being taken as a positive angle and reckoned from the line of fire on either side around to the rear of the gun.

The formulae may now be collected as follows:

$$\text{Influence of the wind} \begin{cases} X_2 = X - WT \cos B & (1) \\ d = \left(T - \dfrac{X}{V \cos a}\right) W \sin \beta & (2) \end{cases}$$

$$\text{Motion of the gun} \begin{cases} X_1 = X + UT \cos \theta & (3) \\ d = UT \sin \theta & (4) \end{cases}$$

$$\text{Motion of the target} \begin{cases} X_1 = X + UT \cos \delta & (5) \\ d = UT \sin \delta & (6) \end{cases}$$

An inspection of the formulae shows that it will be necessary to construct one table showing the corrections to be made for the

influence of the wind, and that one will suffice to show the corrections to be made for the motions of the gun and target. Each class of gun will require its own set of tables.

The plan is evident, and is simply to assume ranges varying from each other as much as may seem desirable; the lowest range probably not less than 1000 yards, and the highest not greater than that given by the gun with 5° elevation. The initial velocity is given in the Ordnance Instructions, where range tables are also to be found.

Then by formulas (1) and (2) compute for variations of 15° of the angle β, and with a fixed velocity of the wind, say 10 miles per hour, the values of the corrections in range and lateral deviation due to the wind, using the times of flight corresponding to the ranges assumed.

The value of the velocity of the wind is suggested at 10 miles an hour, since for any other values the corrections are very easily found, when once they are computed for that assumed velocity, and the labor of computation is lessened. For the corrections due to the motion of the gun and target the process is the same, except that the velocity of the gun and target should be taken in knots, of 6080 feet each, per hour. When suitably arranged, the amounts of the corrections in range and lateral deviation are found by inspection and interpolation from the two tables for the range at which the gun is to be fired; the other arguments being the angle made by the direction of the wind or direction of motion of the gun and target with the line of fire, and the velocities of the wind, gun and target.

It is suggested that the tables be not made too elaborate, so as to require too much time in searching for the desired corrections. Once determined, the correction for range is applied to the sight-bar with its proper sign, and the correction for lateral deviation to the sliding leaf, or rather they are set to allow for them, and the latter requires a small table to use in connection with it.

The sliding leaf on breech sights is usually graduated in minutes of arc, and the divisions mean simply this, that the distance spaced off on the leaf for a division marked for, say, 40′, is the tangent of an angle of 40° when the radius of the circle is the distance between the front and breech sights. Evidently the distance spaced off is found by taking the circular measure of the small angle in question, the radius of the circle being as before stated. The sine and tangent of so small an angle are sensibly equal to the length of the arc itself. The lateral deviation at any distance, due to the sliding leaf being

moved to the 40′ mark, is found in exactly the same way, for example, the radius of the circle is the given range, then the deviation in yards is the circular measure of the small angle given, or the tangent of that angle when the radius of the circle is the range in yards.

If the sliding leaf is not graduated to minutes of arc there is no difficulty, since the distance of any division from the zero mark may be transferred to a scale by a pair of dividers, and we have then two similar triangles from which the lateral deviation due to the sliding leaf being moved any distance may be found for any assumed range.

For illustration, the necessary tables are computed for the 8-in Converted Rifle, initial velocity 1450 f. s., and the times of flight corresponding to the assumed ranges are taken from the Ordnance Instructions, Range Table for this gun, p. 410.

The ranges are assumed at 1000, 1500, 2000, 2500 and 2800 yards; a greater number, differing less from each other, could be taken with additional labor and space occupied.

In using formula (2) it will be found that V may be used for $V\cos\alpha$ for angles less than 5°. For instance, 5° elevation the range of the 8-in. gun is 2817 yards $= 8451$ feet. We have $\frac{8451}{1450\cos\alpha} = 5.85$ and $\frac{8451}{1450} = 5.83$, the difference between the two values may be neglected.

Formula (2) then becomes

$$d = \left(T - \frac{X}{V}\right) W \sin\beta.$$

TABLE I.

FOR INFLUENCE OF WIND. 8-in. M. L. R. I. V. 1450 f. s.

R = correction in range, yards. D = correction for lateral deviation, yards.

Velocity of Wind.	Time. Seconds	Range. Yards.	Angle made by direction of wind with line of fire. 0° or 180°		15° or 165°		30° or 150°		45° or 135°		60° or 120°		75° or 105°		90°	
			R	D	R	D	R	D	R	D	R	D	R	D	R	D
10 Miles per Hour.	2.23	1000	10.8	0	10.5	.2	9.4	.4	7.7	.5	5.4	.7	2.8	.57	0	0.8
	3.48	1500	17.0	0	16.4	.5	14.7	.9	12.0	1.3	8.5	1.6	4.4	1.8	0	1.9
	4.81	2000	23.5	0	22.7	.8	20.4	1.6	16.6	2.3	11.8	2.8	6.1	3.2	0	3.3
	6.23	2500	30.5	0	29.4	1.3	26.4	2.6	21.5	3.6	15.2	4.4	7.9	4.9	0	5.1
	7.11	2800	34.8	0	33.6	1.6	30.1	3.2	24.6	4.5	17.4	5.5	9.	6.1	0	6.4
20 Miles per Hour.	2.23	1000	21.6	0	21.0	.4	18.8	.8	15.4	1.1	10.8	1.3	5.6	1.5	0	1.6
	3.48	1500	34.0	0	32.8	1.0	29.4	1.9	24.0	2.6	17.0	3.2	8.8	3.6	0	3.8
	4.81	2000	47.0	0	45.4	1.7	40.8	3.3	33.2	4.6	23.6	5.7	12.2	6.3	0	6.6
	6.23	2500	61.0	0	58.8	2.6	52.8	5.1	43.0	7.3	30.4	8.9	15.8	9.9	0	10.2
	7.11	2800	69.6	0	67.2	3.3	60.2	6.4	49.2	9.0	34.8	11.1	18.0	12.4	0	12.8
30 Miles per Hour.	2.23	1000	32.4	0	31.5	.6	28.2	1.2	23.1	1.7	16.2	2.0	8.4	2.3	0	2.4
	3.48	1500	51.0	0	49.3	1.5	44.2	2.8	36.1	3.9	25.5	4.8	13.2	5.4	0	5.7
	4.81	2000	70.6	0	68.2	2.5	61.1	4.9	49.9	6.9	35.4	8.5	18.3	9.5	0	9.9
	6.23	2500	91.5	0	88.3	4.0	79.2	7.7	64.7	10.9	45.6	13.3	23.7	14.9	0	15.3
	7.11	2800	04.3	0	100.8	5.0	90.3	9.6	73.7	13.6	52.2	16.6	27.0	18.6	0	19.2

TABLE II.

Corrections for Motion of Gun or Target.

8-in. M. L. R., I. V. 1450 f. s. R = correction for range, in yards.
D = correction for deviation, in yards.

Speed of Gun or Target Knots.	Yards Range.	δ or θ 0° or 180°		δ or θ 15° or 165°		δ or θ 30° or 150°		δ or θ 45° or 135°	
		R	D	R	D	R	D	R	D
	1000	6.3	0	6.0	1.7	5.4	3.1	4.4	4.4
	1500	9.8	0	9.4	2.6	8.5	4.9	6.9	7.0
5	2000	13.5	0	13.0	3.5	11.7	6.8	9.6	9.6
	2500	17.5	0	16.9	4.5	15.2	8.8	12.4	12.5
	2800	20.0	0	19.3	5.2	17.3	10.0	14.1	14.1
	1000	10.0	0	9.7	2.7	8.6	5.0	7.0	7.0
	1500	15.7	0	15.1	4.1	13.6	7.9	11.1	11.1
8	2000	21.7	0	20.9	5.6	18.7	10.9	15.3	15.3
	2500	28.1	0	26.8	7.2	24.3	13.1	19.9	19.9
	2800	32.0	0	30.9	8.3	27.7	16.0	22.6	22.6
	1000	12.5	0	12.1	3.3	10.8	6.3	8.8	8.8
	1500	19.6	0	18.9	5.1	17.0	9.8	13.9	13.9
10	2000	27.1	0	26.1	7.0	23.4	13.6	19.2	19.2
	2500	35.1	0	33.8	9.1	30.4	17.6	24.9	24.9
	2800	40.0	0	38.6	10.4	34.6	20.0	28.3	28.3
	1000	15.0	0	14.5	4.0	13.0	7.5	10.6	10.6
	1500	23.5	0	22.7	6.1	20.4	11.8	16.7	16.7
12	2000	33.6	0	31.3	8.4	28.1	16.3	22.0	22.0
	2500	42.1	0	40.5	10.9	36.5	21.1	30.0	30.0
	2800	48.0	0	46.3	12.5	41.5	24.0	34.0	34.0
	1000	16.2	0	15.7	4.3	14.0	8.2	11.4	11.4
	1500	25.5	0	24.5	6.6	22.1	12.7	18.1	18.1
13	2000	35.2	0	33.9	9.1	30.4	17.7	25.0	25.0
	2500	45.6	0	43.9	11.8	39.5	22.9	32.4	32.4
	2800	52.0	0	50.2	13.5	45.0	26.0	36.8	36.8
	1000	17.5	0	16.9	4.6	15.1	8.8	12.3	12.3
	1500	27.4	0	26.5	7.1	23.8	13.7	19.4	19.4
14	2000	37.9	0	36.5	9.8	32.7	19.0	26.9	26.9
	2500	49.1	0	47.3	12.7	42.5	24.6	34.8	34.8
	2800	56.0	0	54.0	14.6	48.4	28.0	39.6	39.6
	1000	18.8	0	18.1	5.0	16.2	9.4	13.2	13.2
	1500	29.4	0	28.3	7.7	25.5	14.7	20.8	20.8
15	2000	40.6	0	39.1	10.5	35.1	20.4	28.8	28.8
	2500	52.6	0	50.7	13.6	45.6	26.4	37.3	37.3
	2800	60.0	0	58.0	15.6	51.9	30.0	42.4	42.4
	1000	25.0	0	24.2	6.6	21.6	12.6	17.6	17.6
	1500	39.2	0	37.8	10.2	34.0	19.6	27.8	27.8
20	2000	54.2	0	52.2	14.0	46.8	27.2	38.4	38.4
	2500	70.2	0	67.6	18.2	60.8	35.2	49.8	49.8
	2800	80.0	0	77.2	20.8	69.2	40.0	56.6	56.6
Speed of Gun or Target Knots.	Yards Range.	D	R	D	R	D	R	D	R
		δ or θ 90°		δ or θ 75° or 105°		δ or θ 60° or 120°		δ or θ 45° or 135°	

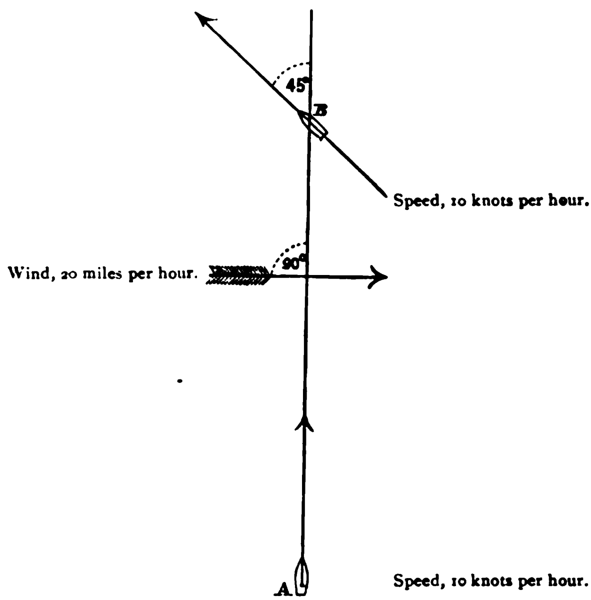
TABLE III.

LATERAL DEVIATION IN YARDS FOR EACH DIVISION ON SLIDING LEAF.

8-in. M. L. R. Distance between Sights 44".5.

Range Yards.	10'	20'	30'	40'	50'	1°
1000	2.9	5.8	8.7	11.6	14.5	17.4
1200	3.5	6.9	10.5	14.0	17.5	21.0
1400	4.1	8.2	12.3	16.4	20.5	24.6
1600	4.6	9.3	13.8	18.4	23.0	27.6
1800	5.2	10.4	15.6	20.8	26.0	31.2
2000	5.8	11.6	17.4	23.3	29.1	34.8
2200	6.4	12.8	19.2	25.6	32.0	38.4
2400	7.0	14.0	21.0	28.0	35.0	42.0
2600	7.6	15.2	22.8	30.4	38.0	45.6
2800	8.2	16.3	24.4	32.6	40.7	49.2

Example.—Suppose a ship at A firing with an 8-in. M. L. R. at a ship at B, which is steering a course making an angle of 45° with the line of fire; A at the instant of firing steering directly towards B and making 10 knots an hour. Wind across the range as indicated in the figure. Distance from A to B, 1500 yards.



From Table I the lateral deviation due to the wind is found to be 3.8 yards.

From Table II the correction for speed of A is -19.6 yards in range. Correction for speed of B, $+13.9$ yards in range, and 13.9 yards lateral deviation. The gun, then, must be pointed to the left of the line of fire to allow for a lateral deviation of $3.8+13.9=17.7$, say 18 yards, and the sliding leaf should then be set to the left at about the 40′ mark; since from Table III it is seen that that distance on the sliding leaf will cause about the deviation required at 1500 yards range. The range is not materially changed; it is 1494 yards, about.

The table showing the effect of the wind is constructed after Professor Hélie's formulas, as previously deduced, and the lateral deviations seem to be large. It is thought, however, that the results will agree fairly with experiment, but until extended experiments shall be made to establish the law of the deviation of projectiles due to the effect of the wind, any formulas are clothed with some doubt. The writer admits that the tables may, perhaps, be more conveniently arranged than has been indicated, and, doubtless, ingenious officers who care to form and use such tables will devise some better plan of arrangement.

A set of tables, if they serve no other purpose, will give an excellent idea of the magnitude of the correction that should be applied in some way, and, if studied, must lead to an improvement in accuracy of fire.

When a ship is turning quickly, the influence of the *angular* velocity given to the gun on the lateral deviation of projectiles is sometimes a very appreciable quantity. If the lock-string is pulled at the moment the gun-captain decides the line of sight bears on the object to be hit, a short interval of time elapses for the charge to be ignited and the projectile to leave the muzzle of the gun. This interval of time evidently varies with the character of the firing apparatus, the powder, the length of bore or travel of the projectile, and other causes, and it is thought that in many cases may equal, if not exceed, .2 of a second. From experiments made by Lieutenant J. F. Meigs, U. S. Navy, at the Naval Academy, with the Schultz Chronograph, it was found that with the Navy percussion-locks the interval between the gun-captain throwing himself back on the lock lanyard and the explosion of the primer was 0.13 seconds, and to this must be added the time for the charge to be ignited and the shot to leave the bore.

Taking the case of a ship which completes a full circle in 4 minutes

as an example, her angular velocity is $1°30'$ per second; and if the interval of time from the moment the gun-captain decides to fire, to the moment the shot leaves the bore, is 0.2, the ship will swing through an arc of $18'$ in that time; hence the lateral train of the gun is changed about that much, and by reference to the table for the sliding leaf of the 8-inch M. L. R., this would cause a lateral deviation of 44 feet at a range of 2800 yards. Except at long ranges and when the turning circle is quickly completed, the influence of this source of lateral deviation will probably not be great, especially if a quick-acting firing apparatus be used, and the gun-captains are trained to fire without any delay the instant the sights bear.

While not strictly within the scope of the foregoing article, the following remarks may be pardonable. From a consideration of the magnitude of the errors that are likely to happen from a neglect to apply proper corrections for wind, speed of gun and target, not to mention the motion of the gun platform, the inclination of the plane of the trunnions, the swing of the ship, and other sources of inaccuracy that may occur, we are naturally led to the conclusion that if we expect to attain proficiency in *accurate* gunnery practice, and if we wish to make these modern engines of war perform all they are capable of doing, a most careful and thorough system of instruction and constant practice is an absolute necessity. The idea is here advanced that the men who are to use the sights and attachments intelligently, and to fire the guns with judgment, to say nothing of the niceties of loading and management of the machinery of the carriage and slide, should be of a higher education and attainments than is the case with the enlisted men who are selected for the most important positions of gun-captains. In other words, it is believed that these positions, in want of a *specially trained corps* of enlisted or appointed men, should be filled, for the heaviest guns at least, from trained junior officers of the ship, including lieutenants, so far as they may be available. That they should not be selected according to rank, but according to their skill, good eyesight, a ready knowledge of the requisites for good shooting, and general qualifications for such a position. That officers would esteem such a post of duty in battle as a high honor is not doubted. This arrangement need not exclude the instruction of enlisted men in the duties of such a position, so that they may perform the duty in the case of casualties.

In this way we may, perhaps, gain in increased efficiency of each gun what our navy may lack in the number of guns afloat.

NAVAL INSTITUTE, ANNAPOLIS, MD.

FEBRUARY 26, 1885.

COMMANDER ALLAN D. BROWN, U. S. N., in the Chair.

THE AVOIDANCE OF COLLISIONS ON THE SEA AT NIGHT, AND THE EMPLOYMENT OF DOUBLE SIDE-LIGHTS.

BY COMMANDER W. B. HOFF, U. S. N.

MR. CHAIRMAN AND MEMBERS.

Gentlemen:—I have the honor of calling your attention this evening to a subject, the importance of which, I feel sure, we will all agree to recognize. It is the avoidance of collisions on the sea at night, and in this connection the employment of double side-lights, so that the course of an approaching vessel may be the more readily and the more accurately determined.

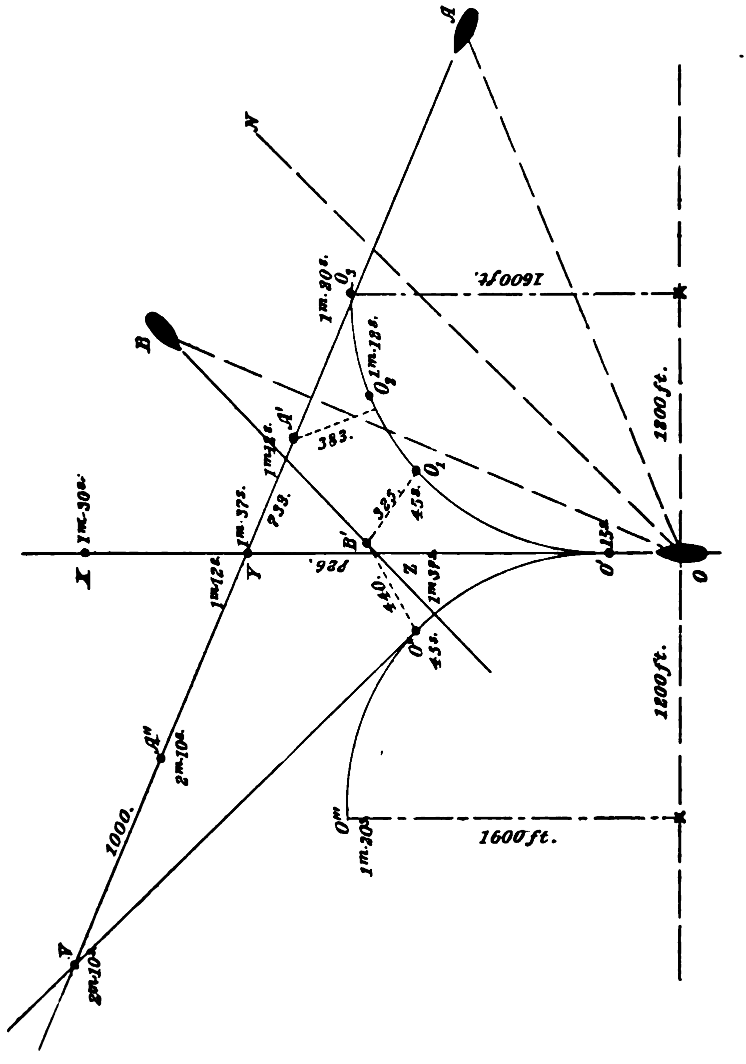
I.

A new Cunarder, the Umbria, has steamed at the rate of twenty and a quarter knots on the measured mile. She is five hundred feet long, and has a displacement of something near ten thousand tons. Here is a condition of affairs on the sea for which we must prepare ourselves, and the first question to be asked is, are the rules of the road as they stand on our statute books applicable to such large steamers, making such great speeds and having such great turning circles, and are the official instructions to pilots in some cases proper ones?

I have here a diagram (Plate 1), where I have laid down to scale the conditions liable to govern two steamers, each moving at the rate of twenty knots, where one would have to manœuvre to keep out of the way of the other.

We notice, first, that O is the vessel, under the law, which must give way and avoid a collision with either A or B, since O has them on

PLATE I.



his starboard side. *A* and *B* are each half a mile from *O*. Let us for the present consider *B* out of the way altogether, and see what *O* must do to avoid *A*.

The distance *OX* is half a mile, which *O* covers in 1 m. 30 s. *O*'s helm begins to act in 15 s. at *O'*, and she turns through 4 points in 45 s. (making allowance always for loss of speed in turning), when she will be either at *O''* or O_1. She turns through 8 points in 1 m. 20 s., when she will be either at *O'''* or O_2. She has advanced when here 1600 feet, and has transferred 1200 feet.

We see that *A* is in the octant lying between a bearing of 4 points on *O*'s bow and his beam, and we will consider her as standing along the line *A V*.

Now *O* can stand on at full speed; slow, and go astern of *A*; stop, and let *A* pass her; turn to starboard or turn to port.

First, then, if we suppose she stands on to *X* at full speed, she will pass ahead of *A* in 1 m. 12 s. at *Y*, 733 feet, *A* being then at *A'*.

If *O* slowed to ten knots, she would be at *Z* in 1 m. 37 s., when *A* would be at *Y*, where she would have passed ahead of *O* 726 feet.

If *O* stopped, and Professor Osborne Reynolds is correct in saying that she would come to a state of rest in six or seven times her length, independent, or nearly so, of the power developed by her screw when backing, the ship would be somewhere between *B'* and *Y*, dead in the water; time required being between two and three minutes. The chances are that *A* will have by this time passed safely ahead, but it might happen that *O*, not being under control, might, from a false appreciation of *A*'s speed and course, arrive at *Y* just in time to have *A* ram her.

Now suppose that *O*, instead of controlling her speed to clear *A*, used her helm. In the instructions given to pilots, under the present statute, by the Board of Supervising Inspectors of steam vessels, we find that when *O* must manœuvre, the two vessels being situated as in the diagram, she must put her helm to port, and pass *astern* of the other vessel, while *A* must continue on, or "*port her helm*" if necessary. This last instruction is clearly opposed to the International Regulations, which, although not *law*, distinctly state that where one vessel is to manœuvre, the other vessel *must* keep her course.

Now would it be proper to port in this case? I think not. If *O* did she would be at O_2 in 1 m. 12 s., when *A* is at *A'*, and they would have approached one another within 385 feet. Rather close quarters, so close that a slight misjudgment of *A*'s speed on the part of *O*

might make her do the very thing she was trying her best to avoid, *ram A*, since it will be observed that *O*'s course cuts the line along which *A* is standing at O_8.

As we know, there is one thing more that *O* can do, she can starboard her helm and turn to port. Suppose that she does so through 4 points to *O''*. This will take her 45 seconds. If now from here she stood on, at full speed, along the line *O'' V*, she would pass ahead of *A* at *V* (*A* then being at *A''*) in 2 m. 10 s. at a distance of 1000 feet. Of course *O*, after she gets to *O''*, can elect with safety to slow or stop, or use her helm to pass astern after *A* has arrived sufficiently on her bow.

I take it that manœuvre is best which brings about the best results. That is, the vessels being on *safety points*, or those positions where the danger of collision is passed, the conditions governing that movement which makes the separation of these points the greatest distance, and which makes the ships' courses the more nearly parallel throughout the manœuvre, is the best. Therefore I should conclude from the diagram that the best thing for *O* to do is to STARBOARD; and for this reason I term the octant in which *A* is located the OCTANT OF STARBOARD HELM.

Let us now take into account the case of *B* and *O*. We see that *B* lies in the octant *XON*, or on a bearing between ahead and four points on the starboard bow of *O*. *B* is steering a course *BC*, and *O* must manœuvre to avoid her, as in the case of *A*. If *O* and *B* stood on they would collide at *B*, if we considered that their speeds were equal. If *O* slowed or stopped, the same thing might happen, the distance separating them being so short. If *O* starboarded her helm and turned to port she would be at a safety point *O''* in 45 seconds, when *B* was at *B'*, separated 440 feet, and *O*'s keel line at right angles to *B*'s. But if *O* ported her helm, her turning circle lying inside of that of *B*'s course, would be at all times clear of *B*; and although in passing they would come within 325 feet of one another, still their courses would be nearly parallel. The danger of collision can, of course, be lessened by *O*'s slowing. Turning to starboard for *O* is unquestionably the proper course for her to take, and so we can call the angle *XON* the OCTANT OF PORT HELM.

II.

It was not until the autumn of 1864 that the carrying of side-lights of the present system by vessels became compulsory. Almost from

the time that steamers made their appearance at sea, a red light and a green light were carried, but this was without force of law. The only recognized light for vessels at sea was the bowsprit cap-light—a white light—and before this, prudence had dictated a lantern carried forward to show over the ship's side when necessary.

Admiral Ammen suggested in 1860 a light to be carried by sailing vessels on the bowsprit cap. It consists of a lantern divided into three parts. The starboard side green, showing from two points abaft the beam to two points on the bow, or through eight points, the port side showing red through the same arc. That portion of the lantern from two points on the starboard bow to two points on the port bow showed white. Here is what may be said to be the beginning of the system of double side-lights, since there was a danger octant shown. That is, there was a sector of two points on each side of the fore and aft vertical plane shown by the white light.

Undoubtedly as soon as commerce on the sea began, or armed flotillas for war or rapine traversed the waters, the necessity for some means of indicating a vessel's position became apparent, therefore at night a flame of some kind was exhibited. The museums furnish us with many forms of the *cressets* or fire baskets which were carried by the galleys of the middle ages, and later on we come across the elaborate lanterns which adorned the poops of the flagships of the Genoese and Venetian admirals and those of the superior officers of the fleet—works of beauty which might have come from the forge of Quentin Matsys, or from the atéliers of any of the Italian masters of this craft. This state of lighting, white lights forward and lanterns of different colors on the poops, continued until very recently. In the days of the sailing ship an approaching vessel was warned off by a lantern swung over the side. When steamers came in, it became necessary, from the increase of speed and from not having the wind as a factor of normal reference for courses, to show more nearly, by some signal, how a vessel was standing, hence the colored side-lights; so that now-a-days we can tell within ten points how a vessel is steering. But higher speeds exact a more intimate knowledge of the course of the other vessel, and for this reason the suggestions of practical men to gain this knowledge have all pointed one way, the employment of more lanterns. I will not discuss in this paper the means and methods which should be used to insure a good, bright, steady and reliable illumination of the side lanterns, but I shall confine myself to showing you the principal systems designed to accom-

plish the end I have spoken of. I am aware that in order to do this, bad elements as well as good are brought into the question, but I am of the opinion that the *advantages* of using *more* lanterns greatly preponderate.

It may be stated concisely that the disadvantages are greater cost and a greater number of lights to be kept burning, consequently a greater likelihood, in case one of the lights is obscured, that collisions will happen through a wrong appreciation of the vessel's course. The advantage is that we know how the other vessel is steering within less than ten points, and therefore we can proceed at higher speed, while the danger of collision is thus lessened.

Since there are people who are color blind, and since a white light can be seen a longer distance than can one which is colored, there has often been a move made to substitute groups or arrangements of white lamps, and to do away with colored screens. Unfortunately there is much to interfere with this scheme. There is, however, one arrangement which in a way takes in this element, and is the *very best*, but which, it is to be regretted, is not applicable to sea-going vessels. We mean the *range light*, but we will pass by its consideration at present and will discûss it further on.

The white light is the illuminant by which the human eye sees at night; therefore should side-lights be merely some new arrangement in, or repetition of this color, it might happen that circumstances could combine to produce the wrong impression, so that a collision would be courted. Take for instance the suggestion that three white lights, one above the other, should show the starboard side, and that two white lights disposed in the same way should indicate the port side. An accidental putting out or shutting out of one of the starboard lights, something very likely to occur, might give the impression that the port side of the ship was visible to you. Again, a deck lantern improperly exposed above the port light would lead you to suppose that you saw the vessel's starboard side.

In my opinion, this possibility would more than offset any error liable to arise from color-blindness. If the side-light—either a red one or a green one—was extinguished, although a collision might occur from the fact that the ship approaching was not seen, still there could be no *misleading* as in the case of white side-lights.

From what has now been said I think that we are confined to *colors*, and I am of the opinion that the solar spectrum does not furnish any others more distinctive than those now used.

III.

Methods have been devised to show how the helm is put, by means of signal lights being displayed to the other ship. In one system for steamers a whistle is also automatically blown to show the condition of the helm. In another system the way the helm is put is shown by a second side-light, perhaps of a different color, surmounting the regular side-light. These ideas as regards lights are all fundamentally vicious, all equally bad. Imagine the confusion likely to arise by a green light appearing in company with a red one, or a red light surmounting a green one!

Should it become necessary to apprise an approaching vessel of the state of your helm, nothing is better than the blasts of the steam whistle as now laid down, and which in my opinion should be incorporated in the international rules of the road.

Since the year 1871 all steam vessels whose cruising is confined to sounds, bays, estuaries and rivers of the United States, have, in addition to the ordinary lights carried by vessels at sea, displayed a white light on a pole at the stern, to show above the white light at the bow. This range-light, as it is called, shows unobstructedly around the horizon. The lights now carried are, as we know, two colored side-lights, green to starboard and red to port, showing from ahead to two points abaft the beam on each side, through ten points, and which are invisible half a point on the other bow. As we know, this is the outfit for sailing vessels, and for steamers we add the mast-head white light, showing through twenty points from ahead through ten points on each side. When we add the white range-light aft, which shows all around the horizon, we have a vessel ideally lighted. I can think of no better way, since every change of direction is immediately shown. But unfortunately its use is not applicable to the open sea. The drawback being that it cannot be seen when sail is set; again, smoke and the large tops in men-of-war, now larger than ever, since mechanical gun fire from aloft is necessary, interfere with its efficiency; but the principal reason is, that the rolling of the ship destroys the range, and so we reluctantly leave it to look at some of the substitutes furnished us to gain this end. This is generally brought about by the employment of more than one light of the same color, or of different colors, on the same side of the vessel, which arrangement is generally known by the name of Double Side-Lights. But there are some systems which have this object in view, and at

which we intend to give a passing glance, where the side-lights as now fitted are disposed in some regular figure, any change in which shows a change of course for the ship.

There is one, for instance, where the side-lights and mast-head light are arranged in an equilateral triangle in a plane parallel with the midship section. The advantage of this system is that the course of the vessel is indicated nearer than ten points, by the practiced eye marking the angle made by a line passing through the mast-head light and one of the side-lights and the horizon. The disadvantage is that the mast-head light would generally have to be carried too low, or else the side-lights would have to be carried on outriggers, and therefore the plan is hardly feasible.

Another method is to have the mast-head light carried so far aft of the side-lights that when the ship presents a beam view, a line passing through the mast-head light and one of the side-lights makes an angle of 45° with the horizon, and when the eye of the observer is four points on the bow the mast-head light is right over the side-light. The plan, if it were practicable, would be fairly good, but generally vessels are so sparred and rigged that it cannot be done.

Admiral Ammen suggests that steamers carry the ordinary side-lights, and his light for a mast-head light. This would be in many ways an improvement, and I regret that I cannot show it on my model, with which I hope to demonstrate to you practically this evening the value of the systems I am now bringing to your notice. If there is any drawback to this method it will be found, I fancy, in the sails, smoke and top-hamper obscuring it and making the colored shades non-effective.

IV.

One of the first to present a system of double side-lights was Captain von Littrow. Here is a diagram which shows his method (Plate II, Fig. 1). It will be noticed first, that neither of his lights shows abaft the beam. There is a light of the proper color on each side, showing from ahead to abeam, and in addition to these side-lights there are other side-lights of the same color, showing, through an arc of four points, from four points on the bow to abeam. These second lights are placed as far aft as possible. All these side-lights are in the same horizontal plane. It will be easily seen that the ship's course with this system of lighting is more closely known. If one light is seen, the ship is heading within four points of a course which

PLATE II.

Fig. 1.

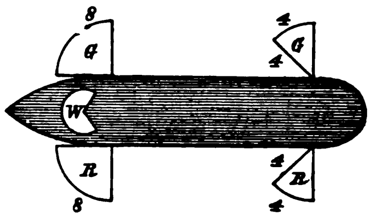


Fig. 2.

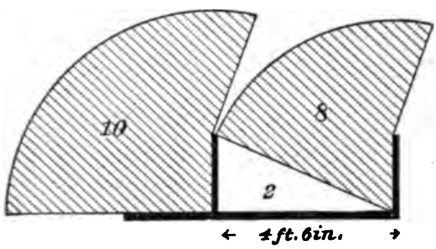


Fig. 3.

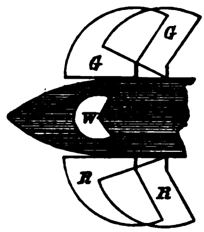
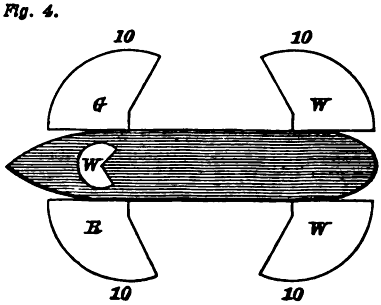


Fig. 4.



is the opposite of your bearing from her. If two lights are seen, the ship is heading between four points and eight points of the direction you are bearing from her.

Now the disadvantage of this arrangement of lights is that the lights being separated as far as possible and being on the same horizontal plane, the conditions in a long steamer would be such that she might be mistaken for a steamer and a sailing vessel astern of her.

As regards distances between lights, we see here (Plate II, Figs. 2 and 3) a plan almost the opposite of the foregoing, the two lights being arranged in the same light-box only 4 feet 6 inches apart, and on the same horizontal plane. This system is the invention of Mr. George Tracy Parry, of Philadelphia. A Naval Board reported last April that they had had practical workings with it on the Delaware River, and had found that the lights were too near together. This we can easily see is the case, and since they are both in the same horizontal plane they blend at even short distances. Again, although the most dangerous sector, the two-point sector, is shown by *one* light (and I would call your attention to the fact that this is a good point), supposing that each light could be seen for itself if we were within the illuminated arcs; still, outside of this the ship's course is not known within eight points, since the after light shows through this many points.

Let us next look at the system proposed by Señor Giralt—a Naval Instructor in the Spanish Navy (Plate II, Fig. 4). Although his idea is something rather different from double-side-lights, still, in the arc extending from two points forward the beam to two points abaft the beam, two lights, a red and a white, or a green and a white, are seen, and the vessel's course may be said to be indicated within four or six points. This method of lighting was intended to furnish additional safeguards to navigation, and was contrived to show one ship, overtaking another, the presence of the leading ship. In other words, a vessel's lights were to be seen from every point of the compass. These are really good points for a system of lighting to possess, but the accidental showing of a white light—a deck lantern for instance—abaft the red might lead another vessel to suppose that safe courses were being steered when in fact a collision was imminent. This alone would do away with all possible good of such side-lights as these. Vessels stopped, with the likelihood of being rammed in the stern by an approaching steamer, would do well to have a light waved over the stern, but I do not think that there would be any use to habitually illuminate ships in this way.

The system of Captain Manzanos of the Spanish Navy next claims our attention (Plate III, Figs. 3 and 4). Here is a second light in range, which shows through six points, between one point on the bow and one point forward of the beam. This light is elevated any height above the after one, which has the common arc (ten points) of illumination. Now it will be noticed that one light will be seen by an observer located on a bearing half a point forward the beam of the ship (which will then be crossing the other's bows, and each will be safe from the other); and that the same conditions of only seeing one light will take place when the observer is located half a point on the bow of this vessel, when each will probably be in imminent danger of collision. Again, two lights being seen, the distance between them being arbitrary, where this was small, as in a short ship, it might have the appearance of a larger ship steering a course heading more nearly for you. This might or might not add to the danger of a collision, but it would certainly add to one's perplexity.

I think all the advantages of double side-lights appear in the system which I submitted to the Bureau of Navigation of the Navy Department in 1883. Here it is! (Plate III, Figs. 1 and 2). We have the ordinary side-lights forward, and twenty metres directly abaft them and at two metres elevation, a side-light on each side, of the usual color to show from ahead to four points on the bow. The distance between the lights, and the height of the after-light above the forward-light, are *invariable* for every vessel. It will be observed that two lights will be visible when the vessel is steering for you within four points; also, that the range is preserved throughout and is properly made, the after-light being the higher, and not as in the system of Captain Manzanos, where the contrary is the case. Then again, the lights being always the same distance apart, both in the vertical and horizontal measurements, and that distance being sufficiently great to prevent blending, and small enough to make the system applicable to small steamers, the eye will become accustomed to the angles subtended by the two lights for the different courses steered by the ship, so that I fancy the direction in which the vessel is standing, whose two lights are seen, can be determined within one point. I am also of the opinion that all the bad qualities inherent in the other systems are overcome in this. If we turn to this diagram (Plate IV), I think we will discover the advantages of this method. You will remember that at an early stage of this paper we called the octant which corresponds to *A* the octant of starboard helm, and the

PLATE III.

Fig. 1.

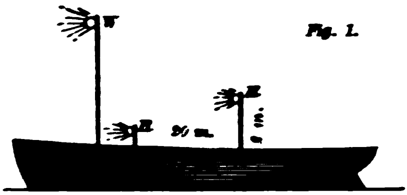


Fig. 2.

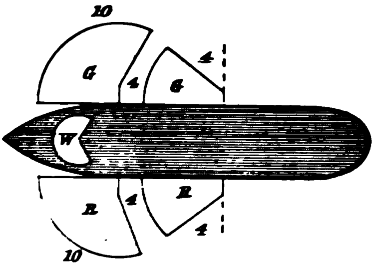


Fig. 3.

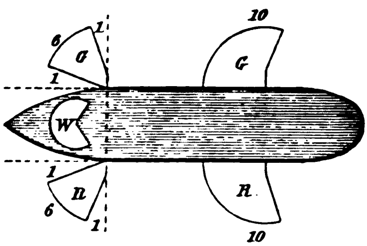


Fig. 4.

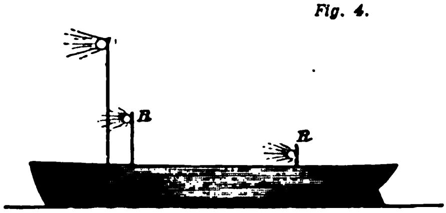
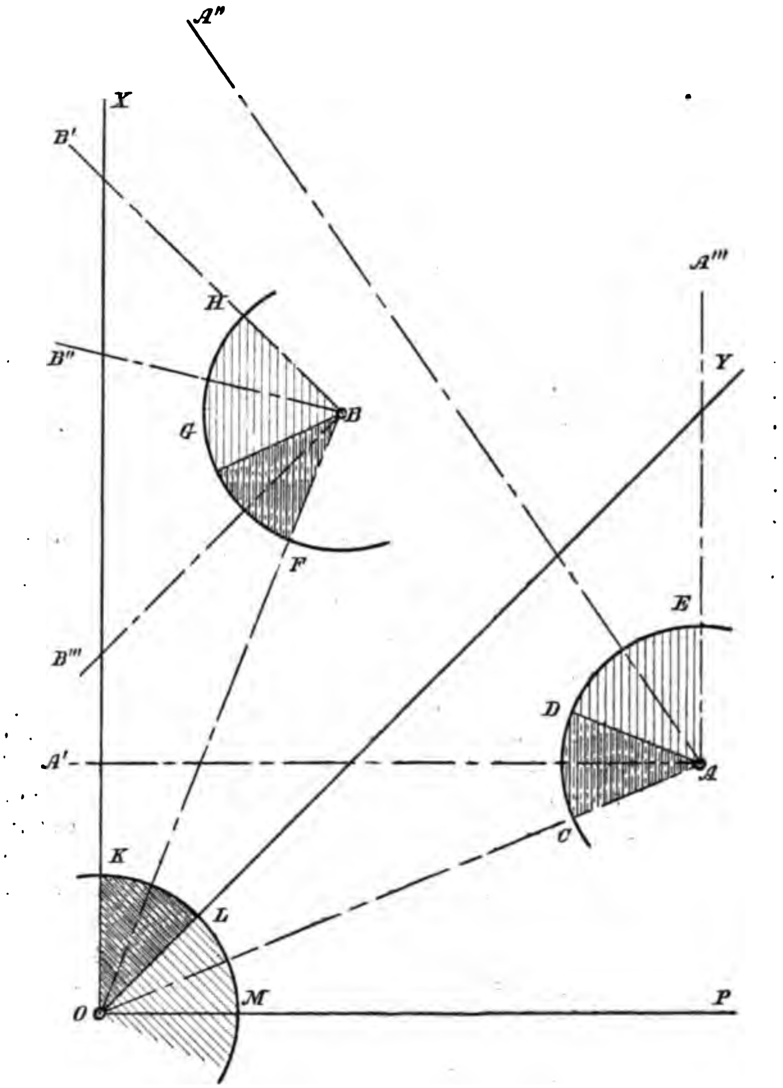


PLATE IV.



octant which corresponds to B the octant of port helm. Now, the positions in this diagram are precisely the same as regards bearing as those which occur in Plate I, and O, which is steering a course OX, must manœuvre to avoid collision. First, let us consider A. If two lights are seen, A must be steering for you, as we have said, within four points, or somewhere in this darker shade between DA and CA. Her general course will be along the line AA', and the distance she must make to collide with you is so great that you could certainly go ahead of her without danger, or at most you would have to ease the slightest off to starboard, supposing, of course, that the speeds of both vessels are considered as equal. Now if only one light is seen, then A is steering somewhere between four and ten points of your bearing, in this lighter shade, or between DA and EA, in the general direction AA''; or your courses, in other words, are converging, and therefore the danger of collision is probable on the other side of X on the line OX. So I call this octant YOP the *danger octant for one light*, or, to lay down a rule: *When you make one red light in the octant between four points on your starboard bow and a bearing abeam, use your starboard helm to avoid collision, turning completely round and going under the vessel's stern if necessary.*

Now let us consider B. Here if she shows *two lights* to O she will be steering somewhere in the sector GFB on the general course BB'''. As we have before said, O should port immediately, and slow, stop or back, or a collision will occur about B'''. If only *one light* is seen by O, then B is steering somewhere in the sector GBH on the general course BB'', and will certainly clear O, especially if O slows. A collision, therefore, is most likely to occur when two lights are visible, and so I call the octant XOY the *danger octant for two lights;* and since it is also the octant of port helm, the rule of the road may be stated thus: *If you make two red lights to starboard, between ahead and four points on the bow, put the helm hard to port immediately, and if the lights look near, slow or stop and back.*

I do think though that it would be better if B in this case was also made to manœuvre—to port *her* helm and turn through 4 points. It would not complicate matters, as the rule would read: *Vessels making two lights between ahead and four points on the bow of the other color than what they show, must put their helms hard-a-port and turn through enough points to shut in one light, slowing if necessary.*

It might be urged in opposition to what I have said that the duty

would be so divided that in case of collision the blame could not be attached to either; but we know that under all circumstances the *other* vessel did the wrong thing, and there would be as much of a chance for a court to decide under the rule I have laid down as there is now.

I wish now to say a word upon a subject which formed the basis of a communication I had the honor to send the Department.

The fact cannot be ignored that as a nation we are not sea-faring. In the old days, before the newer portions of our country were accessible, the spirit of adventure sought the sea as the theatre of his exploits. In case of war now—and it will be a naval war—we will not have the same hearty emulation as existed in 1812 between the hardy fishermen of Massachusetts Bay and the Gulf of Maine, the dexterous pilots of the Delaware, said to be the best sailors in the world, and the daring men of the Chesapeake, but we will find ourselves almost without trained men of the sea. True, we can find plenty who follow the various sea-trades, the stoker, the fireman, the boatman, and the man aloft; but the skilful steersman, the trained lookout, are wanting, and so I conceive that we must lose no time in gathering together and educating material which will be needed at the very outbreak of hostilities.

In my opinion this condition is best met by recognizing that there is, beside the seaman gunner, a co-ordinate outgrowth for the Naval apprentice, the *intelligent Helmsman*, who is developed through the *Signalman*. I will not weary you with the requirements of the different grades into which he is put, how he is paid when there, and under what circumstances he goes from grade to grade, according to his attainments in the line of study I have laid down, or how he must be neither short-sighted nor color-blind; but I will say that the course goes systematically, from holding a deck lantern properly to understanding all sorts of signals, including those made by electricity. Now while the Signalman is in this school, he is being developed coördinately all the time, and he becomes in turn the messenger, the quarter lookout, the lee helmsman, the leadsman, the bow lookout, the weather helmsman, the Coxswain and the Quartermaster. These conditions being fulfilled, our navy could be expanded at pleasure, since vessels could be commissioned and go immediately to sea with men whose training brings the handling of the vessel to the highest standard, and diminishes to a minimum the chances of collision.

Before closing this lecture and showing you how the systems we

have been discussing look upon the model I have here with me, I would say that since such a bad state of affairs exists as regards rules of the road and the lighting of ships, which together with color-blind and short-sighted people add needlessly to the dangers of navigation, would it not be well for us as a nation to call upon maritime powers to join us in a Congress to which these things will be referred? I feel certain the necessity exists, and the sooner we get about it the better. In conclusion, I can only urge upon the members of this Institute and others who are here this evening, to use all their influence in this direction, and in conclusion, to permit me to thank them for their kind attention.

NAVAL INSTITUTE, ANNAPOLIS, MD.

GRAPHICAL METHOD FOR NAVIGATORS.

By Commander C. D. Sigsbee, U. S. N.

For Star Identification, Great-Circle Sailing, True Bearings of Heavenly Bodies, Hour Angle and Altitude of Bodies on the Prime Vertical, and, in general, for the Approximate Solution of Spherical Problems.

Introduction.

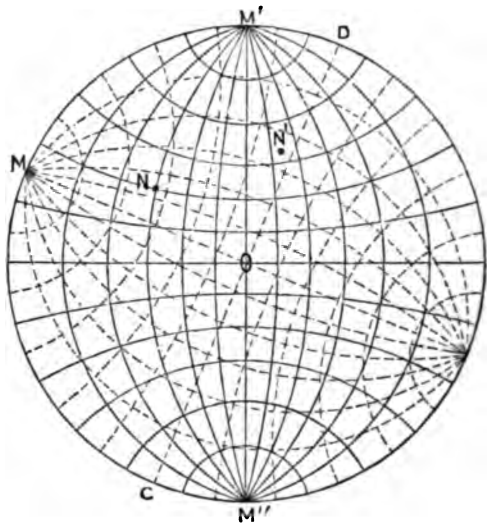
The appended diagram is a stereographic projection of the sphere containing great circles and parallels, at intervals of one degree, for the measurement of spherical coördinates. The novelty of the graphical method consists in the adaptation of this single projection, or system of circles, to the measurement of more than one system of coördinates in the solution of the same problem.

In the figure on the next page let us suppose that the full lines, consisting of a system of great circles and parallels, with M' and M'' as the poles of the latter, have served to project the points M and N, the coördinates of which are given.

Let us suppose, further, that M is one of the poles of a similar set of parallels in combination with a similar set of great circles, and that to this system of dotted lines — which serve for the measurement of another system of spherical coördinates—the point N is to be referred for the solution of a problem.

To make the explanation more practical, let us assume, 1st, that the full lines consist of vertical circles, or circles of azimuth, and parallels of altitude; the *primitive*, or bounding circle, being the meridian of the observer, M' his zenith, and that, having the azimuth and altitude of a heavenly body given, we have projected its place, N, upon the figure; 2d, that M is the elevated celestial pole, the dotted lines hour circles and parallels of declination, and that we require the hour angle and the declination of the body at N.

If the graduations of the primitive and of the dotted diameter or equinoctial, CD, were properly numbered we would simply have to note the parallel of declination and the hour circle passing through the point N, follow one to the primitive and the other to the equinoctial, and take readings, in order to find the declination and the hour angle of the body, that is to say, the coördinates of the point N according to the system of coördinates measured by the dotted lines.



So long as the relative positions of the two points, M and M', remained the same, such a figure would serve for the solution of similar problems involving any other position of an interior point N; but, since the relative positions of M and M' are constantly changing in practice, no two sets of lines similar to those of the figure and printed upon a single sheet can be of universal application in the manner described. The object of the writer's method is to overcome this difficulty by adapting the system of full lines to serve the purpose of both systems for all positions of M and N.

The position of N with respect to the dotted lines is defined by its position relative to the points M and O. Since the two systems of lines are similar, if we transfer N to N' so that N' shall have the same position with respect to M' and O that N has with respect to M and O, then N' will have the same relation to the full lines that N

has to the dotted lines, and we may therefore let *N'* represent *N*, and the system of full lines, in connection therewith, represent the system of dotted lines.

Briefly, then, the method is to first assume that the full lines represent a system of spherical coördinates to correspond with given data, and then to project *M* and *N*; next to transfer *N* to *N'*, and then to assume that the same lines represent another system of spherical coördinates to which it is necessary to refer *N'* for a solution. Article I explains the graphical method.

While stereographic projection has long been used for the graphical solution of problems in nautical astronomy, by making a special projection of each case, the writer is not aware that any method has ever before been devised by which a single projection is made generally applicable for solutions.

Methods which are similar, to the extent that they adapt prepared stereographic projections to general use to avoid drawing, have been devised by Chauvenet and by Saxby, but both of these methods employ more than one projection or diagram for the purpose.

The writer has never seen Saxby's Spherograph, but it is described in several successive numbers of the *Nautical Magazine* (English) for 1856. It consists of two concentric projections, each capable of being revolved about a common pivot at the center, one being transparent. It appears that different sets are employed for different purposes. Judging from the description, it is a less perfect device than Chauvenet's.

Chauvenet's Great-Circle Protractor was formerly issued by the U. S. Hydrographic Office, but it has now become rare. It consists of two concentric projections, one fixed and the other revolving about a pivot at the center. The revolving one is transparent. These projections, which are precisely the same, are on the plane of the meridian like that employed by the writer. The transparent card is objectionable, because it becomes more or less opaque and very brittle in time. In some relative positions of the two projections the maze of lines is such as doubtless to prove an obstacle to its use by those who do not understand the principles on which the Protractor is based, otherwise it is difficult to conjecture why a device so simple in conception has fallen so completely into disuse. Strange to say, Chauvenet gave an imperfect rule for finding the vertex of a great circle upon his Protractor; he overlooked the fact that the vertex is at 90° difference of longitude from the point where the great circle crosses the equator.

The writer has adapted his own method to orthographic as well as stereographic projection, not with a view of publication, but simply as an interesting study. In fact, he had no intention to publish it in any shape until urged to such action by some of his brother officers.

The method now published is exceedingly simple, and is correct in principle; but accuracy of result depends upon the precision attained in projecting points and in reading from the graduated scales. A person of only ordinary skill will doubtless be able to project and read to one-quarter of a degree in most cases, which may perhaps be regarded as excessive accuracy for great circle courses, and sufficient for true bearings. The diagram in the size given does not serve to find the longitude from a "time sight," because a result to the nearest minute is sought; but for the partial determination of Sumner lines it suffices, as will be shown. For star identification it is especially well adapted, as the stars used by navigators are separated by considerable angular distances. It is cheaper, more compact and more easily lighted than a celestial globe, and affords more accurate measurements than ordinary globes of the same diameter.

Although only the general knowledge of nautical astronomy possessed by every navigator is requisite to solve the problems given herein, a better acquaintance with that subject will enable those using the method to greatly extend its application upon the diagram.

The writer does not, in a general sense, recommend his method as a substitute for computation; he simply submits it as a legitimate means of solving certain problems which may be more acceptable to those who prefer graphical methods when they can be employed to advantage, and also as offering in its applications a wide range for study. He believes, however, that a beginner in navigation, especially one with but little acquaintance with mathematics, can gain an intelligent working knowledge of the problems given incomparably quicker by his method than by computation.

A diagram like that given herewith is being prepared for publication by the U. S. Hydrographic Office, under the direction of Commander J. R. Bartlett, U. S. N., Hydrographer, who has consented to this advanced publication. That diagram will be printed for issue on both sides of a heavy Bristol board, and the board will then be coated with a thin, transparent mixture known as "ivorine." Pencil marks may be easily erased from the "ivorine" surface. The following pages are copied from the manuscript prepared for the

Hydrographic Office. Although much of the matter is elementary to members of the Naval Institute, it is deemed best to treat the subject as if for general publication.

General Graphical Method.

Article I. The following elementary, graphical process forms the basis of solutions; its special application to each case is explained in its proper place. See sheet containing the diagram.

Figure 1. Having projected upon the diagram two points, as M and N, given in position, one upon the primitive, or bounding circle, and the other within, conceive a sector MOC whose radii OM and OC shall include these points. Conceive this imaginary sector to be revolved about O until M coincides with some other given point upon the primitive, as M'; then find N' the revolved position of N. *The radii need never be drawn.*

There are various ways of finding N', but the following are suggested. The first is always available, and involves marking points only upon the diagram; the second requires a piece of tracing paper, but makes no marks whatever upon the diagram.

Since one case embraces all, let it be required to revolve the sector MOC about O until M coincides with M', and find N'. Since M will traverse the arc MM', the point C will traverse an equal arc CC'.

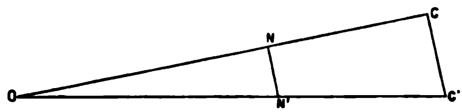
1st Method. Align a straight-edge on O and N to find the point C. Make the arc CC' equal to the arc MM' either by the divisions upon the scale of the primitive, or by transferring the chord MM' to CC' with a slip of paper. Align a slip of paper on O and C and mark upon it the points O, N and C. Then align the slip on O and C' so that its marks O and C shall coincide with O and C' of the diagram, respectively. The point N of the slip will be N', the revolved position of N.

2d Method. Lay a piece of tracing paper (or, as a makeshift, writing paper greased and rubbed thoroughly dry) upon the diagram and trace the points M, O and N. Revolve the tracing about O until M coincides with M'; the traced point N will fall at N'.

In the explanatory Figures 1 to 8, lines of the diagram are represented by full lines, imaginary and traced lines by dotted lines. *Although letters of reference are used the rules are general.*

The diagram should be kept dry because it is intended to be an exact circle. Should it become eccentric so that one radial line, as

ONC (Fig. 1) will be of a different length from another, as *OC'*, to find upon the latter the revolved position *N'* of the intermediary point *N*, proceed as follows, referring to the figure below: from some point, as *O*, on a slip of paper draw lines duplicating the lines *ONC* and *OC'* of the diagram, making any convenient angle with each other. Join *C* and *C'*, and through *N* draw a parallel to *CC'* cutting *OC'* in *N'*. Then use the line *ON'C'* instead of the line *ONC*.



To find the Name of an Observed Star.

Article II. Frequently a star favorable for observation cannot be referred to the surrounding constellations because of cloudiness, and therefore cannot be identified. In such a case measure the altitude as usual, noting the Greenwich time. At the same time, or immediately afterwards, take a compass bearing of the star. Correct the observed bearing for variation and deviation, and reckon it from north in north latitude and south in south latitude; this will give the star's azimuth or true bearing near enough for our purpose. Correct the altitude. Find the latitude and longitude by account, and the local mean time of observation by applying the longitude in time to the Greenwich time of observation. A navigator will always know his latitude and longitude near enough.

Graphical Solution.

The diagram is first assumed to be a projection of the celestial sphere composed of azimuth circles, or vertical circles, and parallels of altitude. *M'* is the zenith, and the line *AB* the celestial horizon. The primitive is the celestial meridian of the observer.

Figure 3. With the azimuth inspect the scale of *AB*, and reckoning from either extremity, find the star's azimuth circle.

With the true altitude inspect the scale of the primitive, and reckoning from either extremity of *AB*, upwards, find the star's parallel of altitude.

The projected place, *N*, of the star is at the point where its azimuth circle intersects its parallel of altitude.

Reckoning from the same extremity of AB as in finding the azimuth circle, find upon the primitive, above AB, the point, M, corresponding to the latitude. M is the place of the elevated celestial pole.

Conceive a sector, MOC, whose radii shall include M and N. Revolve the sector about O until M coincides with M'. Find N', the revolved position of N (Article I).

The diagram is now assumed to be composed of hour circles and parallels of declination. M' is the elevated pole, AB the equinoctial, or the celestial equator, and N' the place of the star.

Read the declination upon the primitive at the parallel of declination passing through N', reckoning from the nearer extremity of AB. When the parallel is above AB, the declination is of the same name as the latitude; when it is below AB, the declination is of the contrary name to the latitude.

Take the reading upon AB at the hour circle passing through N', reckoning from the extremity of AB opposite to that from which the azimuth was reckoned. Convert the degrees and minutes into time. This time will be the hour angle of the star east or west of the meridian according as the star is observed east or west of the meridian.

Having the hour angle, find the star's right ascension by the rule given below, then scan the star tables of the Nautical Almanac and find the name of the star having (approximately) the given right ascension and declination.

To find the Star's Right Ascension. To the right ascension of the mean sun (Nautical Almanac, page II), corrected for the Greenwich mean time of observation, add the local mean time. The result will be the sidereal time. If the hour angle of the star is east of the meridian, add the hour angle to the sidereal time, or if west of the meridian subtract it from the sidereal time, and we have the R. A. of the star, that is:

Star's R. A. $=$ Sidereal time $\pm$ Star's H. A.

or, Star's R. A. $=$ R. A. mean sun $+$ L. M. T. $\pm$ Star's H. A.

Example.

The method of solution is shown in Figure 3, which represents the diagram.

At sea May 10, 1884, P.M.; latitude 27° 15′ N., longitude 89° 30′ W. True altitude 43° 15′, corrected compass bearing or azimuth N. 110°

W., Greenwich M. time of observation 13h. 12m. Right ascension of the mean sun for Greenwich time, 3h. 16m. 56s. The star is Procyon, whose tabulated right ascension is 7h. 33m., declination 5° 30′ N.

In Figure 3, AE is made equal to the azimuth of the star, and the arc BL to its altitude; then $M'E$ is the azimuth circle of the star, LL is its parallel of altitude, and N is its projected place. AM is made equal to the latitude, then M is the place of the elevated pole. MOC is the sector.

$M'OC'$ is the revolved position of the sector, N' the revolved position of the star, and M' the revolved position of the elevated pole. $M'F$ is then the hour circle and DD the parallel of declination of the star. BF is the measure of the hour angle $BM'F$, and BD of the declination.

TO FIND THE HOUR ANGLE AND ALTITUDE OF A HEAVENLY BODY ON THE PRIME VERTICAL.

ARTICLE III. If its declination is greater than the latitude, a body does not cross the prime vertical; if less, it crosses above the horizon if of the same name as the latitude, below if of the opposite name. Any case may be solved by the diagram; but the passage above the horizon being the one of practical use to navigators, the directions which follow are intended for that case.

The data required for effecting a solution are the approximate latitude and longitude of the place of observation and the approximate declination of the body.

Hour Angle. The angle obtained from the diagram is the hour angle of the body east or west of the meridian, according as the time of east or west passage is sought. In the case of the sun, therefore, when converted into time, it is the local apparent time of west passage; and its difference from 12 hours is the local apparent time of east passage. In the case of any other body, to find the *time* of passage apply its hour angle in time to the time of the body's meridian passage.

GRAPHICAL SOLUTION.

The diagram is first assumed to be a projection of the celestial sphere composed of hour circles and parallels of declination. M' is the elevated pole, and AB the equinoctial, or the celestial equator. The primitive is the celestial meridian of the observer.

Figure 4. With the declination inspect the scale of the primitive, and, reckoning from either extremity of AB upwards, find the parallel of declination of the body. Similarly, find the point M corresponding to the latitude. M will be the zenith of the observer.

A right line OM will be the upper branch of the prime vertical, and its intersection, N, with the parallel of declination will be the point of transit.

Read the hour angle upon AB at the hour circle passing through N, reckoning from that extremity of AB which is adjacent to M.

Since the time of passage is now known approximately, if the latitude and longitude are accurately known, greater accuracy of solution may be attempted if desired. Having the local apparent time and the longitude in time, find the Greenwich Mean, or apparent time, to which reduce the declination of the body. With the corrected declination, repeat the operation upon the diagram. This repetition is not likely to be needed excepting when the latitude and declination are nearly equal, especially when both are small; *i. e.* when the prime vertical OM intersects the parallel of declination at an acute angle.

To find the altitude, revolve the imaginary line OM about O until M coincides with M', and find N', the revolved position of N; that is, make ON' equal to ON with a slip of paper.

Now assume that the projection is composed of vertical circles and parallels of altitude. AB is the celestial or rational horizon, M' the zenith, $M'M''$ the prime vertical, and N' the point of transit.

Read the *true* altitude upon the primitive at the parallel of altitude passing through N', reckoning from the nearer extremity of AB.

EXAMPLE.

The method of solution is shown in Figure 4, which represents the diagram.

Required the sun's altitude on the prime vertical and the times of east and west passage in latitude 37° N., when the declination is 17°15′ N. By computation the true altitude is 29°31′; time of west passage 4h. 22m. 40s., east passage 7h. 37m. 20s.

BD is made equal to the declination and BM to the latitude, then DD is the sun's parallel of declination, M the zenith, OM the upper branch of the prime vertical, N the point of transit, $M'E$ the hour circle through N, and BE the measure of the hour angle $BM'E$.

$M'O$ is the revolved position of MO and N' the revolved position of N. $N'L$ is the parallel of altitude through N' and AL is the measure of the true altitude ON'.

To Find the True Bearing or Azimuth of a Heavenly Body.

Article IV. True bearings of heavenly bodies for determining compass error, or the direction of Sumner Lines of Position, may be found from the diagram when either the latitude, declination and hour angle, or the latitude, declination, and altitude are given. The application to Sumner Lines is explained in Article V.

The total compass error is found by comparing the compass bearing of any body with its true bearing at the same time. The deviation of the compass for the direction of the ship's head at the time of observation is found by applying to the total compass error the magnetic variation for the place of observation. The magnetic variation is commonly given by the sailing chart.

Note the Greenwich time of observation. If the latitude and longitude are not known by observation, find them by account. Reduce the declination for the Greenwich time, and correct the altitude when the latter is used.

Hour Angle. For use with the diagram, reckon the hour angle both east and west through 12 hours. The hour angle of the sun west of the meridian is the local apparent time of observation, found by applying the longitude in time, and the equation of time to the Greenwich mean time of observation; the supplement (to 12 hours) of the local apparent time is the hour angle of the sun when east of the meridian.

The hour angle of the moon, or a planet, or a fixed star for the time and place of observation is found by the following formula:

H. A. of body = Sidereal Time of Observation — R. A. of body,

or H. A. of body = R. A. of mean sun + L. M. T. — R. A. of body.

When the angle found by the formula exceeds 12 hours, its difference from 24 hours must be used.

Convert the hours and minutes of the hour angle into degrees and minutes.

Graphical Solution.

Case I.— *When the Latitude, Declination and Hour Angle are known.*

The diagram is first assumed to be a projection of the celestial sphere, composed of hour circles and parallels of declination. M' is the elevated pole, and AB is the equinoctial, or the celestial equator. The primitive is the celestial meridian of the observer.

Figure 5. With the hour angle inspect the scale of AB, and, reckoning from either extremity, find the hour circle of the body.

With the declination inspect the scale of the primitive, and reckoning from either extremity of AB, find the parallel of declination of the body, which must be sought above AB when the declination is of the same name as the latitude, but below when of the contrary name.

Mark the place, N, of the body where its hour circle intersects its parallel of declination.

Reckoning upwards from that extremity of AB which is *opposite* the one from which the hour angle was reckoned, find upon the primitive a point M corresponding to the latitude.

Conceive a sector, $M'OC$, formed by radii to include M' and N. Revolve the sector about O until M' coincides with M, and find N' the revolved position of N. (Art. I.)

Now assume that the projection is composed of azimuth circles and parallels of altitude. M is the elevated pole, M' the zenith, AB the celestial horizon, and N' the place of the body.

Upon AB, reckoning from that extremity adjacent to the elevated pole, read the true bearing or azimuth at the azimuth circle passing through N'. Reckon the bearing from north in north latitude and from south in south latitude, and towards the east or west as the body is east or west of the meridian or as the hour angle is reckoned east or west of the meridian.

Expeditious method of finding a series of true bearings of the same body.—When a ship is manœuvred to get a series of compass bearings of a heavenly body, for deviation on the several points of the compass, the time thus occupied will generally be so short that the change in declination during the interval may be disregarded, and the declination as well as the latitude assumed to be constant throughout the series. The true bearings of the body corresponding to all the observations of the series may then be found at one operation upon the diagram.

The graphical solution is effected as follows: Mark the place M as before, then lay a piece of tracing paper upon the diagram, and project upon the former, $N_1N_2N_3$, etc., the intersections of the several hour circles with the parallel of declination of the body. Trace the points O and M'.

Revolve the tracing about O until the traced point M' coincides with M. Read the several true bearings upon AB at the azimuth circles passing through $N'_1N'_2N'_3$, etc., the revolved positions of $N_1N_2N_3$, etc., respectively.

Example under Case I.

The method of solution is shown in Figure 5, which represents the diagram.

In latitude 34° 30′ S., find the true bearing of a body when its declination is 10° north, and its hour angle 3h. 10m. (47° 30′) east of the meridian. The true bearing by computation is south 125° 31′ E. or N. 54° 29′ E.

In Figure 5, AD is made equal to the declination (of the contrary name to the latitude), and AE to the hour angle, then DD is the parallel of declination of the body, $M''E$ the hour circle and $AM''E$ the hour angle. N is the place of the body and $M'OC$ the imaginary sector.

The arc BM being made equal to the latitude, M is the position of the elevated pole after the sector is revolved. MOC' is the revolved position of the sector, N' the revolved position of N, $M'F$ the azimuth circle passing through N', and BF the measure of the azimuth or true bearing $BM'F$.

Graphical Solution.

Case II.—*When the Latitude, Declination and Altitude are known.*

First assume the diagram to be composed of hour circles and parallels of declination, as in Case I.

Figure 6. Mark the point M upon the diagram as before. (In Fig. 6 the assumed data are not the same as in Fig. 5.)

Lay a piece of tracing paper upon the diagram and trace the parallel of declination of the body—or the essential part of it—and the points O and M'.

Revolve the tracing about O until the traced point M' coincides with M.

Now assume that the diagram is composed of azimuth circles and parallels of altitude, as in Case I. M is the elevated pole, and the traced parallel, in its revolved position, is still the parallel of declination of the body.

With the altitude inspect the scale of the primitive, and, reckoning from AB upwards, find the parallel of altitude of the body.

N', the point of intersection of this parallel of altitude and the traced parallel of declination, is the place of the body.

Find the true bearing upon AB at the azimuth circle passing through N'; reckon it from the side adjacent to M, and otherwise as directed in Case I.

Example under Case II.

The method of solution is shown in Figure 6, which represents the diagram.

In latitude 49° 30′ N., find the true bearing of a heavenly body when its altitude is 40° 15′ east of the meridian, and its declination 20° N. The true bearing, by computation, is N. 107° 32′ E. or S. 72° 28′ E.

In Figure 6, AD is made equal to the declination (of the same name as the latitude), then DD is the parallel of declination of the body, which is to be traced. The arc BM being made equal to the latitude, M is the position of the elevated pole after the tracing is revolved about O.

$D'N'D'$ is the revolved position of the traced parallel of declination. AL is made equal to the altitude, then $LN'L$ is the parallel of altitude of the body when M is the pole. N' is the place of the body. $M'F$ is the azimuth circle passing through N' and BF is the measure of the true bearing or azimuth $BM'F$.

Partial Determination of Sumner Lines.

Article V. The Sumner Line of Position is perpendicular to the true bearing, or line of bearing, of the observed body. From this property, if we compute two points in the line of position and project the line upon the sailing chart, we may find from it the true bearing; or if we compute one point in the line and find, by any means, the true bearing or line of bearing of the body for the time and place of observation, we may determine the line of position upon the chart by projecting the point and drawing through it a right line perpendicular to the line of bearing. In the latter case the diagram will give the true bearing with the accuracy required for navigation.

An error of a whole degree in the true bearing — an error greater than is at all likely to occur in using the diagram — produces an error of only one mile in the line of position upon the chart at a distance of sixty miles from the established point, while close to the latter it is practically nothing.

The true bearing may be found as described in Case I or Case II of Article IV, according to the data used.

The line of position may then be projected upon the sailing chart by means of a parallel rule and the compass rose of the chart, or by the following method which will generally give greater accuracy:

By means of a protractor draw somewhere near the established point, a right line making with a parallel of latitude an angle equal to the azimuth or true bearing, and in a direction to be perpendicular to the line of bearing of the body. With the parallel rule draw a parallel to this line through the established point. The second line will be the Sumner Line of Position.

GREAT-CIRCLE SAILING.

General Remarks.

ARTICLE VI. The many conditions necessary to be considered in the selection of an extended ocean route demand for each case a special judgment, but, since in nearly all cases the chief object in view is to shorten the voyage or passage, whatever scheme tends to this end should be weighed according to its merits. It cannot be said that this is commonly done in respect to great-circle sailing.

There are three routes which offer great advantage over the simple rhumb route, and one or another of which may generally be adopted: 1st, the great-circle or direct route; 2d, the meteorological route, often circuitous but passing through regions of favorable winds and currents; 3d, a compound route, made up of a meteorological route embracing stretches upon great circles.

A glance at a globe makes it apparent that the shortest distance between any two places upon the surface of the sphere is upon the great circle which joins them, and that it is only while maintaining her great-circle course that a vessel heads for her port as if it were in sight. Excepting when sailing along a meridian or the equator the course upon a great circle changes continuously with the advance of the vessel, but so slowly that in practice it need be changed, generally, only for each 100 or 200 miles of distance made good. Since the great-circle course for any position of the vessel is quickly found, a necessity for a change of the course is made known. From what has been said, it is seen that a vessel in going over a great-circle route actually sails upon a series of rhumbs closely approximating to a great circle.

It is, unfortunately, too common a practice amongst navigators to accept the straight line of the Mercator chart as a direct route. Apart from magnetic variation, this practice offers a theoretically constant course; but since magnetic variation must be taken into account, and since it is impracticable to long maintain the original

straight line, a constant course is seldom realized excepting for short distances.

The rhumb line of the sphere is a spiral which has the property of making a constant angle with meridians, but upon the Mercator chart it projects as a straight line and thus presents a fallacious appearance of minimum distance. The chart only serves to direct a vessel's course and to mark her progress; the vessel actually sails upon the sphere, and, when her course is shaped by the rhumb, she approaches her port or place upon a spiral.

Every great circle intersects the equator at the extremities of a diameter of the sphere, and is divided at the equator into two equal parts or semicircles. The *vertex* of each semicircle is that point upon it which is highest in latitude. The two vertices are diametrically opposite points of the sphere; they have the same latitude, but of opposite names, and are at 90° difference of longitude from the points where the great circle and the equator intersect. At a vertex the course is east or west. If in approaching a vertex there is northing in the great-circle course there will be southing after passing it, and *vice versa*. In this graphical method no use is made of a vertex excepting when it occurs on the route to be sailed over.

The saving in distance which a great-circle route offers as compared with the corresponding rhumb route varies greatly, of course, amounting sometimes to hundreds of miles. Between Yokohama, Japan, and Cape Flattery, Washington Territory, the example given herewith, it is 268 miles. A comparison may be made for any two places by subtracting the distance found upon the diagram from the rhumb distance computed by the rule of Mercator's sailing.

A knowledge of the great-circle course is of importance in working to windward, for in blindly following the rhumb the vessel may even be sailed away from her place of destination. The great-circle course frequently varies three or four points from the rhumb course. On the route from Yokohama (Cape King) to Cape Flattery, the great circle course at Cape King is NE., while the rhumb course is E. by N., a difference of three points. In this case, for a wind directly ahead on the rhumb an uninformed commander would lay his vessel on either tack indifferently; if on the port tack, and the vessel work in twelve points, she would head SE. by S., nine points away from her great-circle course, the only course on which she would head directly for her place of destination. On the starboard tack she would head N. by E., only three points away from her great-circle

course. It is quite certain that this vessel would be laid on the unfavorable tack for a wind whose direction was between the great circle and the rhumb courses. Less extreme cases may be assumed and the possibilities investigated by any seaman. It does not suffice to say that the great-circle course is to the northward of the rhumb in north latitude and to the southward in south latitude; in order to know when to go about and make the very best of his way to windward a commander should know the amount of variation of the two courses.

When a great-circle route has been decided upon, the whole route should be projected upon the sailing chart, either by a continuous line, or by frequent points, that it may be subjected to examination for general direction, obstructions, meteorological conditions, etc. When the vessels falls off the original great circle it is not attempted to regain it, for the shortest distance then is upon the great circle which joins her actual position and her place of destination. Her course is always the great-circle course at her actual position, and this may be found from the diagram, or the general direction of the original projected great circle may be followed by shaping rhumb courses by the Mercator Chart; the former method is preferable because more exact.

GRAPHICAL SOLUTIONS.

Let M be the place of departure, and N the place of destination.

To find the great-circle course. First assume the diagram to be a projection of the terrestrial sphere, composed of parallels of latitude and meridians of longitude. M' is the North Pole, M'' the South Pole and AB the Equator. The primitive is always the meridian of the place of departure.

Figure 1. Project M upon the *primitive* in its proper latitude—north or south as the case may be—on the right side if it is the eastern place, on the left side if it is the western place.

Project N in its proper latitude, and upon a meridian whose difference of longitude from M is that of the two places.

Conceive a sector, MOC, formed by radii, to include M and N (Article I). Note, by a glance simply, if N would fall above or below AB, if the sector were revolved so as to make M coincide with that extremity of AB which is adjacent to M. If above, reckon the course from north; if below, from south.

Revolve the sector about O until M coincides with M' or M''—the *nearer* extremity of $M'M''$—and find N' the revolved position of N.

Now assume M' or M''—whichever is the revolved position of M—to be the place of departure and N' the place of destination. The former meridians then become great circles through the place of departure, and the parallels are parallels of great-circle distance from the same place. The scale of AB gives the angle which each great circle makes with the primitive, the meridian of the place of departure, and hence the course.

The great circle passing through M', N' and M'' is the required great circle: read the course at its intersection with AB, reckoning from the nearer extremity of AB. Having the course, reckon it from north or south as previously found, and towards the east or the west as the place of destination is to the eastward or westward.

To find the great-circle distance. Find the great-circle distance upon the primitive at the parallel of distance passing through N', reckoning it from M' or M''—the place of departure—by taking the complement of the reading. Multiply the degrees by sixty and add the minutes; the result will be the distance in nautical miles.

To find the vertex and other points upon the great circle. The quickest method is by means of tracing paper. Trace the required great circle through N', and revolve the tracing about O until M' or M''—whichever is the revolved position of M—coincides with M. The traced great circle will then pass through M and N.

If the vertex is of any use it falls upon the diagram, and it is found upon a meridian at 90° difference of longitude from the point where the traced and revolved great circle intersects AB, the equator.

Take points upon the revolved great circle at 5° or 10° intervals of longitude from M towards N—or, if desired, on both sides of the vertex when it falls between M and N—and find the latitude and longitude of each, measuring latitudes upon the primitive and *differences of longitude from M* upon the scale of AB. Transfer the points to the sailing chart and adjust or "fair" a curve to them.

The more exact method is to take the intervals from M towards N, for the points will then fall upon printed meridians of the diagram. The advantage of measuring from the vertex is that points equally distant in longitude on either side have the same latitude.

NOTE.—The vertex and other points may also be found without tracing paper, as follows, taking the case projected in Figure 1.

The Vertex. Figure 7. Observe which semi-diameter, OA or OB, bisects the required great circle $M'N'M''$, and conceive it to be revolved in the

direction in which the sector MOC (of Fig. 1) was revolved, and through an equal angle at O. The revolved semi-diameter being the semi-equator when the place of departure is at M' (or M''), find its intersection, E, with the required great circle. The vertex, V, of the latter is upon a parallel at 90° from the parallel of E, reckoning in the opposite direction to that in which the semi-diameter was revolved. When the rule fails the vertex is not upon the diagram and is of no use.

Conceive a radius, OR, through V. Revolve the sector $M'OR$ (or $M''OR$, as M' or M'' is the place of departure) about O until M' (or M'') coincides with M. Then V', the revolved position of V, will be the vertex of the required great circle through M.

Other points. Figure 8. Mark the points X, Y, Z, etc., in which the required great circle, $M'N'M''$, is intersected by parallels of distance at intervals of 5° or 10° from the revolved place of departure at M' or M''.

Conceive radii, OR, OS, OT, etc., through the points X, Y, Z, etc., respectively, and when the sector $M'OC'$ (or $M''OC'$) of Fig. 1 is revolved back to MOC, revolve these radii severally in the same direction and through an equal angle at O. Find the revolved positions, X', Y', Z', etc., of the points X, Y, Z, etc. The revolved points will be points upon the required great circle through M; upon the sphere they will be separated by equal distances.

EXAMPLE.

In this example the results are obtained by computation that they may be compared with those obtained from the diagram. This particular great circle is not practicable because it passes north of the Aleutian Group. It is introduced that it may be compared with a composite route between the same places, given in Article VII. Figure 1 represents the diagram and contains the projection of the unbroken route.

Great circle from M, a position in latitude 34° 50′ N., longitude 140° 00′ E., near Yokohama, Japan, to N, a position in latitude 48° 30′ N., longitude 125° 00′ W., near Cape Flattery, Washington Territory.

Position of the Vertex, latitude 54° 08′ N., longitude 160° 12′ W.
First great-circle course, N. 45° 32′ E., true.
Constant rhumb course, N. 79° E., "

Distance on great circle,	4058	miles.
Distance on rhumb,	4326	"
Difference of distances,	268	"

Points upon the Great Circle.

Long. from Vertex.	Latitudes.	Longitudes.	Longitudes.
5°	54° 02′ N	165° 12′ W	155° 12′ W
10°	53° 43′ "	170° 12′ "	150° 12′ "
15°	53° 11′ "	175° 12′ "	145° 12′ "
20°	52° 26′ "	179° 48′ E	140° 12′ "
25°	51° 25′ "	174° 48′ "	135° 12′ "
30°	50° 09′ "	169° 48′ "	130° 12′ "
35°	48° 34′ "	164° 48′ "	
40°	46° 40′ "	159° 48′ "	
45°	44° 22′ "	154° 48′ "	
50°	41° 39′ "	149° 48′ "	
55°	38° 26′ "	144° 48′ "	

In Figure 1, AM is the latitude of M, and BL, or HN, the latitude of N. AH measures the difference of longitude of M and N. MOC is the sector.

$M'OC'$ is the revolved position of the sector, N' the revolved position of N, and $M'N'M''$ the required great circle. The arc $M'D$ measures the great-circle distance $M'N'$, and BG measures the course $BM'G$.

MVE is the revolved or true position of the required great circle, E the point where it intersects the equator, EI the measure of 90° of longitude from E, IVM' the meridian of the vertex, V the vertex, AK, or IV, the latitude of the vertex, and AI measures the difference of longitude of M and V.

Composite Great-Circle Sailing.

General Remarks.

Article VII. When the great circle joining two places ascends into higher latitudes than it is prudent or possible to penetrate, a modified or composite great-circle route may be taken between them. Having determined the highest latitude to which he will sail, the navigator composes his route of an arc of the limiting parallel of latitude, and parts of two great circles whose vertices lie upon this parallel, one great circle passing through his place of departure and the other through his place of destination. He then sails upon the first component great circle until its vertex is reached, thence along the limiting parallel to the vertex of the second component great circle, and finally upon the second great circle to his place of destination. This composite route is the shortest possible under the

restriction of limited latitude. Along the limiting parallel of latitude the course is shaped upon the Mercator chart by the common method of rhumb sailing.

NOTE.—For an example of a composite great-circle route, projected stereographically, see under Professional Notes, "*A Fallacy in Composite Great-Circle Sailing.*"

To find the Vertex, V_1, and other points upon the first component great circle. Let M be the place of departure and N the place of destination.

Figure 2. Project M upon the primitive in its proper latitude as in Article VI.

Lay a piece of tracing paper upon the diagram and trace the limiting parallel of latitude (or a small part of it about where it is judged the vertex will fall), and the points O and M. Revolve the tracing about O until M coincides with M' or M''—whichever is the nearer.

The first component great circle is that which is tangent to the traced parallel in its revolved position. Read the first course upon AB at the tangent great circle. Trace this great circle and revolve the tracing about O until M comes back to its original position.

Obtain points for transfer to the sailing chart as described in Art. VI, and find the vertex, V_1, upon the limiting parallel at 90° from the point where the traced and revolved great circle intersects AB.

To find any course and distance upon the first component great circle. Having found the vertex V_1, treat it as a place of destination, or as N, for finding all courses and distances upon the first component great circle, following the method of Article VI.

To find the vertex V_2, and other points upon the second component great circle. Proceed by the rule prescribed for the first component great circle, but as if sailing *from* the place of destination towards the limiting parallel. That is, treat the place of destination as M; project it upon the primitive on its own side and in its proper latitude; trace the limiting parallel; revolve the tracing about O, and find the tangent great circle as before.

To find the course and distance upon the second component great circle. Treat the place of the ship as M and the place of destination as N. Then proceed as prescribed in Article VI.

To find the distance upon the limiting parallel. Proceed by the rules for parallel sailing as given in books on practical navigation, or

inspect the table on page 268 of Bowditch, new edition, or page 64, old edition.

EXAMPLE.

In the case given in the example under Article VI, assume 51° north as the limiting latitude, and find the composite route between the two places. The following results are obtained by computation.

Figure 2 represents the diagram, and contains the projection of the first component great circle.

Vertex V_1, latitude 51° N., longitude 164° 18′ W. First course, *N.* 50° 04′ E.

Vertex V_2, latitude 51° N., longitude 148° 45′ W.

Distance from M to V_1,	2562 miles.
Distance from V_2 to N,	929
Distance from V_1 to V_2 on the parallel of 51° N. by parallel sailing)	587
Total distance by composite route,	4078
Total distance by rhumb,	4326
Difference,	248

Rhumb course *N.* 79° E.

In Figure 2, AM is the latitude of M, AK the limiting latitude, and KK' the limiting parallel. M''' is the revolved position of M' when M is revolved to M', and $K'K'$ is the revolved position of the traced parallel KK. $M'GM''$ is the first component great circle tangent to $K'K'$, and BG measures the first course $BM'G$.

MV_1E is the traced and revolved great circle when M arrives back at its original position, E the point where it intersects the equator, IE the measure of 90° of longitude from E, $M'I$ the meridian of V_1 the vertex, and AI the measure of the difference of longitude of M and V_1.

Having found V_1, the tracing is again revolved about O until M arrives at M', then V_1' is the revolved position of V_1, and $M'D$ the measure of the distance of V_1 from M.

APPENDIX.

SIMPLE ORTHOGRAPHIC CONSTRUCTION FOR STAR IDENTIFICATION.

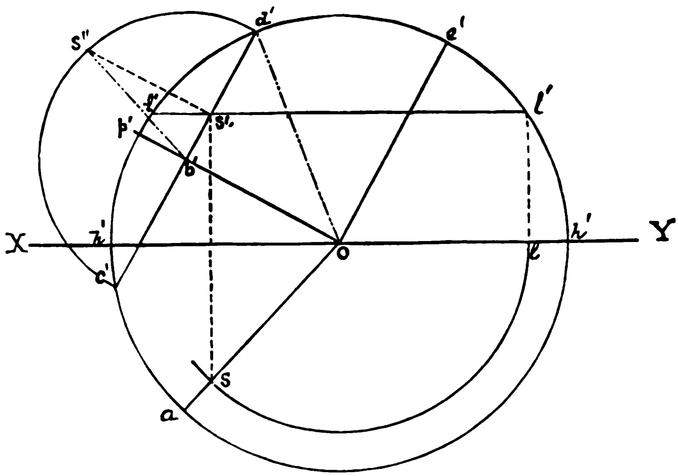
When the stereographic projection, or diagram, is not at hand, the simple special construction shown in the accompanying figure

may be used for star identification, when the data prescribed in Article II is given. The construction will be greatly facilitated by the use of draftsman's triangles.

Describe any circle, $h'd'h'a$, about o as a centre, and draw a diameter $h'h'$. Make the arc $h'p'$ equal to the latitude, $h'l'$ equal to the altitude, and $h'c'a$ equal to the azimuth. Draw the radii oa, op' and oe', making oe' perpendicular to op'. Draw $l'l'$ parallel and $l'l$ perpendicular to $h'h'$. With centre o and radius ol describe the arc ls, cutting oa in s. Draw ss' perpendicular to $h'h'$ and cutting $l'l'$ in s'.

Through s' draw $c'd'$ perpendicular to op', cutting op' in b' and the original circle in c' and d'. With center b' and radius $b'd'$ describe a semicircle $d's''c'$. Draw $s's''$ perpendicular to $c'b'd'$, cutting the semicircle in s''.

The angle $s''b'd'$ is equal to the hour angle of the star east or west of the meridan, as the case may be. The angle $d'oe'$ is equal to the declination of the star. When d' falls on the same side of e' as p', the declination is of the same name as the latitude; when it falls on the opposite side of e', the declination is of the opposite name to the latitude. Having the declination and hour angle, find the star's right ascension as directed in Article II.



Explanation of the Figure. The figure is a projection of one-half of the visible celestial sphere, $h'd'h'$ on the plane of the observer's meridian, and $h'ah'$ on the plane of his horizon. On the vertical

plane $h'd'h'$ is the upper meridian, $h'h'$ the horizon, $l'l'$ the parallel of altitude of the star, p' the elevated pole, op' the semi-axis (or the upper branch of the 6 o'clock hour circle), oe' the semi-equinoctial, s' the place of the star, $c'd'$ the parallel of declination of the star, and d' the point of transit over the upper meridian. The semicircle $c's''d'$ is the parallel of declination, revolved about its diameter $c'd'$ into the vertical plane, and s'' is the revolved position of s'. In the horizontal projection $h'ah'$ is the horizon, oa the azimuth circle, and ls the parallel of altitude of the star. s is the place of the star. This same construction may be used for other problems.

THE TURNING CIRCLE: APPLICATION OF COAST-SURVEY METHODS TO THE DETERMINATION OF.

By Lieutenant A. McCrackin, U. S. N.

The following well-known methods for determining positions are proposed for use in the turning trials of steamers, viz:

Positions determined:

1. By theodolite angles taken by two observers on shore occupying known signal points.

2. By one theodolite angle from the shore and one from the steamer.

3. By two angles from the steamer on three known shore signals (three-point problem).

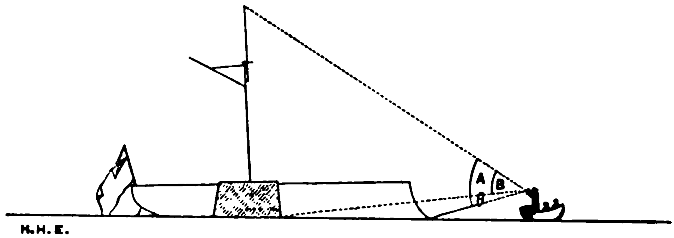
The approximate methods described by W. H. White—*Navy Scientific Papers, No.* 7—are not adequate to our needs; and the method given in General Order No. 314 is not simple, nor applicable to all classes of steamers. The latter method requires outside of the engine-room, two chip observers, two plane-table observers, one compass observer with recorder, and one boat observer with recorder; or eight (8) observers and six (6) watches—so that the chances for personal and time errors are very great, in addition to the difficulty of taking simultaneous observations and consequent trouble in plotting the data.

There are other objections to the required method, which do not arise in those proposed, viz:

1. There are two causes of error in the angle which the boat-observer takes between the steamer's mast-head and water-line:

a. The difference between the observed angles when the steamer is broadside and end-on.

Error, $\theta = A - B$.



b. The difference in height of mast-head due to the heeling of the steamer while turning.

These two errors will, however, be small. Furthermore, unless the boat is moored, neither the bearings and angles taken from it, nor the plane-table angles taken from the steamer, on the boat, are of much value.

In the trials of the Alarm, and the monitors Passaic and Nantucket, the "mast-head" angles were often very small and practically useless.

2. The plane-table angles from the bow and stern are not reliable, on account of the impossibilty of keeping the tables level while the steamer heels in turning.

3. The difficulty in obtaining the true speed from the chip observations; as, in quick-turning steamers especially, it makes a great difference in the apparent speed, on account of the drift, whether the chips are thrown on the side of the steamer which is nearer the centre of the circle, or on the outer side.

4. The compass observations are not accurate, as the compass-card will not travel so fast as the steamer turns; and especially is this true in quick-turning iron steamers like the monitors. Moreover, in iron steamers it is very difficult to obtain the proper deviation to apply to the compass-readings, when the steamer's angular motion is so rapid. It is also difficult to get an object so far distant that there shall be no parallax during the turning trial.

The three proposed methods reduce the number of observers and watches, thus decreasing the personal and time errors, they all eliminate the compass, and they are applicable to all sizes and classes of steamers.

The direction of the steamer's keel is obtained by an observer on board, who takes the angle with a sextant, between a fore-and-aft line and one of the shore signals.

The position of the steamer and the direction of her keel being plotted, and the times being known, we have given all the data necessary for determining her speed, drift-angle, and properties of the turning circle.

If the trial is made during slack water, no correction for current will be necessary; but, if required, an observer in a boat anchored near the place of trial can measure the current. The position of the boat may be determined by the same method used in the case of the steamer. The direction of the current is determined by the boat-observer taking the angle between the log-chip and one of the shore signals; and the strength of a weak current can be measured more accurately by using cod-line and a cone-shaped canvas bag, than by the ordinary line and chip.

Evidently, the third method (three-point problem) is the best one, for the following reasons, viz:

1. The sextant is the only instrument required in taking the observations.

2. The three observers and the recorder may all be stationed together, thus insuring the accurate location of the steamer and the direction of her keel at the *same* instant.

3. The data is ready for plotting as soon as it is recorded, and does not require any comparison or preparation, as in the other methods.

4. The positions are so easily and rapidly plotted with the three-armed protractor.

In determining the Tactical Diameter of the monitor Nantucket, this past summer, the following methods were used:

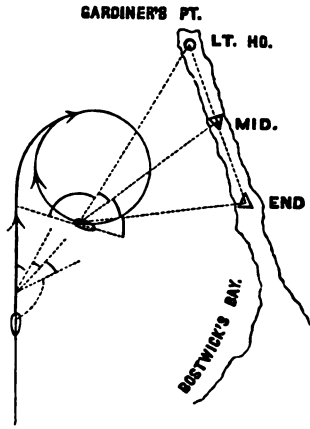
1. The method required by General Order No. 314, which, on acccount of the small values of the mast-head angles, and difficulty of obtaining the speed and drift-angle, was found to be inapplicable. At the same time of using this method, positions were determined.

2. By angles taken by two observers occupying known shore stations. These observers used ship-compasses and azimuth-circles mounted on tripods. The angles gave the position of the steamer; but the work was not all plotted, on account of the inaccuràcy of the plane-table observations for determining the drift-angle.

3. The three-point method, of which the commanding officer of the Nantucket said, he had no hesitation in saying that he considered it by far the best method he had seen tried.

The place selected for this trial was in Gardiner's Bay, L. I.

Only three signals were found necessary, Gardiner's Point Light



House being used as one; they were 3000 feet apart, and in a straight line.

The distance between the signals was measured with a patent-log line, 200 feet long; using a spring balance to secure an equal strain on the line when making the measurements.

The base line was measured, and the two signals erected in one afternoon.

The signals were made out of drift-wood found on the beach.

The following form was used in recording the observations:

No.	Time.	Angle between		Angle between			Remarks.
		End and Mid.	Mid. and Light.	Signal.	Bow or Stern.	Angle.	

The observers stood together on the hurricane deck; and it was found that observations could easily be taken and recorded every 30 seconds.

The keel observer stood amidships, and for a fore-and-aft line used the flagstaff and stancheons.

In plotting the work, tracing paper was used, which made the task more tedious than where a metal three-armed protractor is used. The scale used was $\frac{1}{2500}$.

The three-point method can be used any place where there is a base-line; but it is suggested that, as the measured mile is in Narragansett Bay, the position of shore signals could be there determined from the Coast-Survey triangulation points, and permanent monuments erected. Charts, on a convenient scale, could be furnished from the department, with the signals plotted thereon; and metal three-armed protractors could be kept at the station on Coaster's Harbor Island, for the convenience of those steamers which are not supplied with them.

NAVAL INSTITUTE, ANNAPOLIS, MD.

A NEW METHOD OF MAKING RUNNING SURVEYS.

BY ENSIGN JOHN H. FILLMORE, U. S. N.

A method of sketching in shore-lines when making running surveys or reconnoissances which avoids the necessity of estimating distances, or depending on the eye to get the configuration of the shore-line, or taking bearings with the compass.

The instrument used is a modification of the ordinary plane table, and consists of a plane table or drawing board, mounted on a tripod, and two rulers. One ruler is attached to the edge of the board so as to move freely in the direction of its length across the board, with room underneath it for a sheet of sketching paper. This ruler is pointed at one end, and graduated on one edge from the pointed end as zero. The other is an ordinary straight-edge ruler with sight vanes at the ends, and is not attached to the board in any way. (See Figures 1 and 2, Plate I.)

To sketch in a shore-line, the ship or boat runs along the shore at as uniform a speed as possible, and with as few courses as is consistent with keeping at a convenient distance from the shore; the distance from the shore being determined by the minuteness of the details which it is desired to see and record. The board is mounted on deck so as to command as much of the horizon as possible, and is so placed that the pointed ruler is parallel to the ship's track; ordinarily this will be parallel to the ship's keel. When the ship is making drift or steering a range the ruler is to be parallel to the course actually made; how it can be so placed will be explained hereafter. A line drawn along the edge of this ruler will be the ship's track on the paper. The graduations on this ruler represent time, so that if at any instant its point is at the ship's position on the paper, then at any other time, say three minutes later, the point may be moved forward to the ship's new position by moving it forward three minutes or

three divisions of its graduation. Thus at any instant when the ship is moving along the shore the point of this ruler may be put at her proper position on the paper at that instant; the draughtsman having a watch before him for that purpose. Now to put in the shore-line, bearings are taken of prominent points of the shore with the sighting ruler, having its edge against the point of the time ruler,—the latter being at the proper time or place in the ship's track,—and these bearings are drawn on the paper. As soon as more than one bearing is taken of the same point on shore from different places or times in the ship's track, that point is fixed on the paper by the intersection. It is, in fact, fixed by a triangulation on the point with the ship's track as a base line. (See Plate II.) It is not necessary, of course, to wait for even minutes or divisions of the ruler graduations, but at any instant when a bearing is wanted, the draughtsman, noting the time by the watch, can move the time ruler forward to the proper position, by estimating the fractions of minutes between the divisions. By selecting points as they come in sight on the bow, taking bearings then, again when nearly abeam, and again when on the quarter, good angles can always be made. The whole shore-line is thus put in by cuts on the prominent or necessary points, the draughtsman filling in the shore-line between these points as the ship passes along it. Any number of intersections may, of course, be drawn through the same point to verify the intersections; and many points may be kept in hand at the same time by slight pencil notes on the different lines drawn to keep them from becoming confused. Any prominent peaks or landmarks beyond the shore-line, or in fact anything in sight from the ship in any direction, may be plotted very accurately on the paper by taking bearings of them from time to time as the ship moves along. (See Plate II.)

When the ship's course is changed, turn the paper, underneath the time ruler, through the angle of change about the point of the time ruler occupying the ship's position on the paper at the time of turning, turning the paper to the right when the course is changed to the left, and *vice versa;* the edge of the time ruler will then be along the ship's new track. This angle of change may be laid off with a protractor; or if the ship is to head for a visible point, the new track may be drawn with the sighting ruler, the same as any other bearing, just before turning, and the paper then turned until the edge of the time ruler is along the new track.

The sketch is connected with known points and plotted in the

following manner. The ship is carefully logged,—preferably by frequent readings of the patent log or a careful record of the revolutions of the engine,—and a record kept of the courses and distances, times of changing courses, &c. A time record is also kept on the sketch itself by putting the time down frequently along the ship's track; the separate record of the officer of the deck or other person than the draughtsman being used when finally plotting the work. When the sketch is from one known point to another, these points may be cut in the same as the other points of the shore-line; or the ship's starting and finishing points may be determined by sextant angles on known points or signals. To plot the work, the ship's track is laid down from one known point towards the other, and the second point is plotted from the sketch the same as the other points of the shore-line. Then, all known errors having been eliminated, the difference between the plotted position of this known point and its true position is an error which must be distributed throughout the ship's track. This may be done as shown in the figure. (See Figure 3, Plate III.) The full line represents the plotted track of the ship and the broken line the corrected track. The dotted lines are drawn through the points where the course was changed and parallel to the line through the plotted and true positions of the second known point. And the lines Bc, cc, &c. are of such lengths that Bb is to AB as Dd is to $ABCD$, and that Cc is to ABC as Dd is to $ABCD$, &c. And Dd is equal to Ee. The error is thus distributed proportionately throughout the whole track.

When there is only one known point, a run may be made along the shore-line as far as required and back to the same point, then plotting the whole course; the error in the final plotted position of the known point can be distributed in the same manner.

An examination of this method of making a running survey will render it evident that when running between known points, every error except unrecorded variations in the speed, unknown variations of currents, and unknown irregular errors of the compass, are eliminated; and these are errors necessarily occurring in every running survey not a triangulating one. As before suggested, it avoids all necessity of estimating or guessing distances with the eye, or of depending on the eye for the configuration of the shore-line. It has been found in practice that many irregularities, such as bights and bays in the shore-line which are unperceived by the eye, will be recorded by this method. Such sketching has been done heretofore, when making

running surveys, by the clumsy and inaccurate methods of bow and beam bearings and compass bearings and off-hand sketching. The far greater number and more accurate bearings taken by this method add much to the accuracy of the shore-line obtained. Its rapid and easy use, its self-plotting, and its plotting while the shore-line itself is before the draughtsman, make it especially adapted to places where the shore-line is intricate, as where there are many islands and rocks and many breaks in the shore-line,—a few tangents to an island, from different points in the ship's track, completely defining it.

Various ways of adding to the efficiency of the method will suggest themselves to any one using it. For instance, if the steering is bad or difficult, the draughtsman can, by noting the bearing of some object ahead, know when the ship is exactly on her course, and by only taking bearings then, make the method nearly independent of bad steering. When this precaution is taken, if the bearings of points do not intersect well, then the time ruler is not parallel to the ship's actual course. This should be corrected by turning the board until the time ruler is parallel to the actual course. When the *change* of drift is equivalent to a change of course, then the paper should also be turned a corresponding amount in the opposite direction, the same as for any other change of course. It will be found that the instrument itself will render drift apparent which is hardly discernible in any other way, for when the time ruler is parallel to the true course the intersections will be remarkably close (see Figure 4, Plate III), and any deviation, especially if it repeat itself in successive points plotted, is good evidence of drift, and the amount by which a quarter-bearing fails to pass through the intersection of the bow and beam bearings shows how much the drift is and how much the board is to be turned to correct for it. Figure 4 is an exact copy of the intersections of a number of bearings taken of a point on shore from a ship going about six knots an hour and about two miles off the point; no precautions being taken to favor the method,—the quartermaster at the time was steering an ordinary course, not knowing that anything depended on his steering, and the bearings were taken haphazard as the ship went by the point, as a test of the method.

This method of making a running survey was devised and used on board the U. S. C. S. Hassler in the summer of 1883. Although the instrument there used was made on board ship, it was found to work exceedingly well; many miles of surveying were done with it, both in steam launches and in the ship itself. It was used for putting

Plate I.

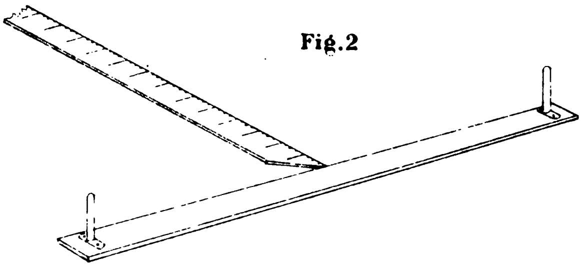


Fig.2

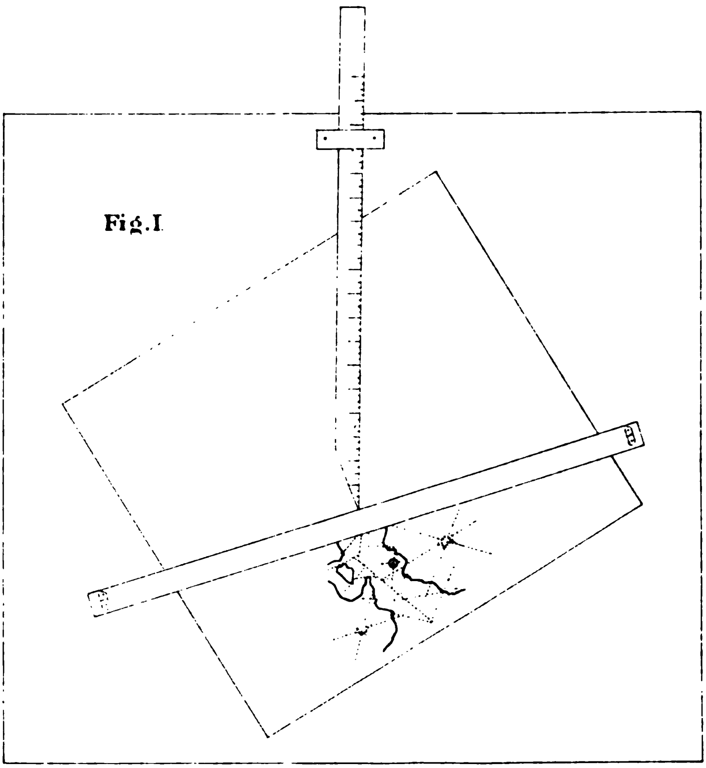


Fig.I

some sixteen specialists from the Army, Navy, and the corps of Mining Engineers and Engineers of Powders and Saltpetre (among whom we note Sarrau, Sebert, Cornu, Vieille, Desortiaux and others), and in this position he has the assistance of a considerable laboratory force and all the resources of a highly centralized government at his command. It is then not surprising that, by April 5, 1883, his committee had completed twenty distinct researches, and had twenty-three others in course of execution.

The work now under consideration is based principally upon these researches, together with those of Berthelot and others in pure chemistry. The first part deals with the general properties of explosive substances, their chemical composition, the heat disengaged in their explosion, and the pressure of the gases produced; the duration of the explosive reaction; explosions by influence, and the explosive wave. The second part treats especially of the thermo-chemistry of explosive compounds, a chapter being devoted to the much-vexed question of the origin of the nitrates; and the third part considers the force of the explosive bodies. The work is replete with descriptions of the apparatus used, the methods pursued and the data obtained in these researches; but, as we have already noticed, in these Notes, many of the results as they have appeared in the professional journals, we will simply present the following tabular summary:

Nature of the explosive substance.	Formula.	Molecular weights in grams.	Heat disengaged at constant volume by one kilogram in calories.	Volume of permanent gas (1) per kilogram, in litres.	Specific pressure from experiments (3) (1 gram in 1 cm.³) in atmospheres.	Velocity of the explosive wave per second, in meters.
Oxygen and hydrogen.	H_2+O	18	3833 liquid water 3278 steam (1)	1240	11960	2810
Chlorine and hydrogen............	$H+Cl$	36.5	603	610	4940	"
Carbon monoxide and oxygen.......	$CO+O$	46	1483	480	4510	1089
Ethane and oxygen........	CH_4+O_4	80	2669 liquid water 2419 steam (1)	840	11420	2287
Ethine and oxygen.................	$C_2H_2+O_5$	106	3001 liquid water 2907 steam (1)	630	8630	2482
Ethene and oxygen.................	$C_2H_4+O_6$	124	2753 liquid water 2592 steam (1)	720	9940	2209
Cyanogen and oxygen...............	$C_2N_2+O_4$	116	2263	580	8760	2195
Nitrogen sulphide.................	NS	46	694	485	8270	"
Nitroglycerine....................	$C_3H_5O_3(NO_2)_3$	227	1579 liquid water 1480 steam (1)	713	10950	5000 in 75% dynamite.
Nitromannite......................	$C_6H_8O_6(NO_2)_6$	452	1526 liquid water 1459 steam (1)	692	11500	"
Gun cotton........................	$C_{24}H_{29}O_9O_{11}(NO_2)_{11}$	1143	1074 liquid water 1022 steam (1)	859	10000	5000 to 6000
Potassium picrate.................	$KC_6H_2(NO_2)_3O$	267	781	549	$\frac{5600}{n-0.14}$	"
Mercury fulminate.................	$C_2H_2N_2O_2$	284	463 gaseous mercury (2) 349	314	6200 27400 (4)	"
Diazobenzol nitrate...............	$C_6H_5N_2(NO_3)$	167	688	818	about 7600	"
Gunpowder........	74.7 nitre 10.1 sulphur 14.2 carbon 1.0 water		720 to 738	278 to 263	$\frac{2193}{n-0.68}$	"

(1) This volume represents the reduced volume. In those cases where the reaction produces aqueous vapor, the volume of this substance is included in the reduced volume, whereas in fact it is only gaseous at some temperature t higher than 0°; that is to say, the volume assigned to the aqueous vapor ought to be multiplied by $1+\frac{t}{273}$, t being the temperature produced at the moment of the explosion. But then the heat disengaged ought to be diminished by the amount absorbed in vaporizing the water, a quantity which Berthelot takes, for simplicity, as equal to 10000 cal. for 18 grams of water. He neglects on the other hand the effect of dissociation, since the value to be assigned this has not yet been determined. (2) The mercury is supposed gaseous, as it is considered at a temperature above 360°. The real volume is then $314\left(1+\frac{t}{273}\right)$. The heat disengaged has been diminished by the latent heat of vaporization of mercury. (3) These pressures represent the limit toward which the observed pressures tend under a *density of loading* of $\frac{1}{n}$ (1 gram of matter in n cm.³) when n tends towards unity. In the case where a non-volatile residue is produced, the volume of this residue ought to be deducted from n, as is done in the cases of potassium picrate and gunpowder. (4) In its own proper volume, that is to say, for a density of loading when $\frac{1}{n}=4.43$.

In citing these results of Berthelot's work, it may be proper to call attention to a recent review by Prof. Remsen, *Am. Chem. Jour.* **6**, 423, Feb. 1885, of "A Treatise on the Principles of Chemistry," by M. M. Pattison Muir. He says: "Chapter IV is devoted to the *Applications of physical methods to questions of chemical statics.* Of the physical methods the first considered are the thermal methods. The subject is treated clearly; indeed, it would be difficult to find anywhere a more satisfactory statement in regard to the method and results of thermo-chemistry than we here have included within fifty-odd pages. After showing that the thermal value of even the simplest chemical change is really the sum of various changes, some of which have a positive and others a negative value, and that in most, if not in all cases, it is impossible to assign values to each of the simple changes involved, the conclusion is drawn, that until 'the distinction' implied in the terms atom and molecule 'is practically recognized in thermal chemistry, we cannot expect any great advances to be made in applying the mass of data already accumulated to questions of chemical actions and reactions.'

'Berthelot's work is saturated with the conceptions of the molecular theory; but, by some fatal perverseness, he refuses to apply this theory to chemical phenomena. While recognizing the existence of molecules, and building his generalizations on a molecular foundation, he refuses to accept the conception of atom, or rather he hopelessly confuses it with that of equivalent. The molecule is for him a definite and definable portion of matter, the parts of the molecules are only numbers.'

"This criticism may sound harsh, but it appears to be just. At all events we shall be glad to hear what the disciples of Berthelot may have to say in reply. We commend this part of the book to the careful attention of those who have blindly 'pinned their faith' to investigations in the field of thermo-chemistry. While something has been learned, and much more will be learned, in regard to the nature of chemical action by a study of thermal phenomena, it must be acknowledged that the results thus far reached are extremely meagre." In this connection consult the same Journal **5**, 147 and 293, also **6**, 202.

Through the courtesy of Manuel Eissler we have received a copy of his "Modern High Explosives," in the form of a large octavo of 495 pages, published by John Wiley & Sons, 1884. The

book is arranged in three parts; the first of which describes the processes employed in the manufacture of high explosives, and the methods of analysis and chemical properties of these bodies and their constituents; the second treats of the methods for operating with these explosives; while the third deals with the principles of blasting, and gives the results obtained in many engineering, mining and military operations. Mr. Eissler designed, erected and managed the American Forcite Company's works,* and has had considerable experience in the use of high explosives, and hence he has been able to gather together and present in the last two parts of his book a large amount of information and data which will be of value and use to the practical man in determining the amount of an explosive necessary to do a given work and the best way of applying it. The first part, on the other hand, is quite unsatisfactory, as it is so marred by errors in chemical terminology and technical phrases as to be quite bewildering.

One of the most novel and interesting chapters in the book is the one on "Big Blasts," where, among other instances, it is stated that it sometimes happens in the system of hydraulic mining in vogue in California, that banks of gravel are met with which are so firmly cemented together as not to yield readily to the action of the water, while other banks are so high that it becomes dangerous to bring the stream sufficiently close for the water to exert its disintegrating force. Under these circumstances recourse is had to what is termed "bank-blasting," in order to loosen the earth so that it will break down under the pressure of the water, and enormous quantities of explosives are used for this purpose. Mr. Eissler gives a detailed description of the method of laying these charges, and he says that in the diggings at Smartsville, San Juan, More's Flat, Bloomfield, and elsewhere in California, it is an almost daily occurrence to fire blasts where twenty, thirty, and even fifty thousand pounds of explosives are used in a single charge, and that this system of large blasts is even become common in hard rock excavations, such as quarries and railroad cuttings.

We learn that a second volume is in course of preparation, and from the scope of the projected work it promises to be of great value.

A circular from the Judson Powder Company gives the following instances of "big blasts," in which this powder has been used:

* Proc. Nav. Inst. 11, 98.

June 29th, 1882, 23,000 pounds were fired in a limestone quarry at Glendon, Pa., and it is estimated that it moved 150,000 tons of rock. January 11, 1883, 29,000 pounds of frozen powder were fired at the same place with good results. At Shell Rock, on the Oregon R. and N. Co. R. R., 10,000 pounds of powder, in one charge, moved 56,000 yards of solid rock. At Jacob's Ladder, on the same road, 21,000 pounds of powder moved 110,000 yards of solid rock.

Through the kindness of Gen. Abbot we are in receipt of Addendum II of his Report on Submarine Mines,* in which the results of recent experiment on Atlas powder, Judson powder, Rackarock, Forcite, and explosive or blasting gelatine, are given.

Two grades of Atlas† powder, A and B, were used, of which the composition was:

Grade A.—	Sodium nitrate,	2
	Wood fibre,	21
	Magnesium carbonate,	2
	Nitroglycerine,	75
		100
Grade B.—	Sodium nitrate,	34
	Wood fibre,	14
	Magnesium carbonate,	2
	Nitroglycerine,	50
		100

The firing trial showed Atlas A to be precisely equivalent to dynamite No. 1, when fired under water; while Atlas B, under the same conditions, showed an intensity of action in the horizontal plane equal to 99 per cent. of dynamite No. 1, for equal weights.

Several grades of Judson powder‡ were tested. The one most commonly used, and which is sold at the price of common saltpeter blasting powder, is the R. R. P., which has the composition:

Sodium nitrate,	64
Sulphur,	16
Cannel coal,	15
Nitroglycerine,	5
	100

* Proc. Nav. Inst. 9, 287, 754. † Proc. Nav. Inst. 11, 116.
‡ Proc. Nav. Inst. 11, 116.

It is manufactured at the New Jersey works by first grinding the niter, sulphur and coal separately, to a fine powder, and then thoroughly incorporating them in a barrel mixer to form a coarse mealed powder. This is then heated on a steam pan (150 pounds pressure and 350° F.), and constantly stirred until the sulphur melts and coats the particles of the niter and coal. The mass is then thrown out and allowed to cool, and it forms conglomerate grains, which are sorted by sieves and coated with nitroglycerine by stirring. The theory of this manufacture is the same as that claimed by Mr. Mowbray for his mica powder, viz: the coating of a non-absorbent base with nitroglycerine, by which the quickness of explosion is promoted. The prime difference between the powders lies in the fact that Judson employs an explosive base, while Mowbray's is inert. The advantage sought for here is to obtain the maximum potential energy of the explosive base through the initial action of the small charge of nitroglycerine.* The intensity of action of the R. R. P. of different makes, fired under water, was found to equal 38 to 39 per cent. of dynamite No. 1, while some of the other grades rose as high as 78 per cent. The lower grade seemed to be insensitive to the shock of the ball from a Springfield rifle at twenty paces, and when ignited by a match, in charges of 1½ pounds, it burned for about forty-five seconds with a strong yellow flame, but with no such flashing as occurs with ordinary gunpowder.

In addition to the rackarock mentioned in these Notes,† Mr. Divine, the inventor, has patented several other formulas in which the potassium chlorate is finely powdered and mixed with nitro-benzol and sulphur, or with "dead oil" of tar and sulphur, or with "dead oil" of tar, sulphur and carbon disulphide in varying proportions. Several of these mixtures were tested and they gave results varying from 77 to 104 per cent. as compared with dynamite. Gen. Abbot seems to be favorably impressed with this explosive and recommends its trial in blasting and for use in shells.

The forcite gave results which varied, with the grade, between 88 and 133 per cent., and hence it compared favorably with Nobel's explosive gelatine. It was found that the higher grade was the more liable to sympathetic explosions, but that both those tested were much less sensitive than dynamite No. 1 under similar conditions. When the forcite-gelatine was exposed for several hours to a

* Proc. Nav. Inst. 8, 665.

† Proc. Nav. Inst. 9, 755.

temperature of 100° F., a slight exudation of nitroglycerine was observed. The manufacturers state that the base for all grades of forcite* is mixed with a special kind of "cellulose" whose formula is $C_6H_7O_2 \begin{cases} NO_2 \\ C_2H_3O_2 \end{cases}$, which permits them to operate and manufacture cold. As they state that in manufacturing Nobel's gelatine a temperature of 170° F. is necessary for incorporation, and that this temperature renders the nitroglycerine very sensitive to concussion and quite dangerous to transport, they claim the cold process as an advantage. A hydrocarbon is used as a solvent for the forcite mixture, and its action renders the product water-proof.

The blasting gelatine used in these experiments came from Nobel's Explosive Co. of Glasgow, Scotland. It was without camphor, but directions for easily camphorating it are given. The composition was 92 per cent. nitroglycerine and 8 per cent. nitro-cotton. The test gave the relative intensity as 142, showing this to be the most powerful explosive yet tested at the station. Its sensitiveness to sympathetic explosion was the same as that of the higher grade of forcite.

Gen. Abbot gives a tabular view and also a graphical diagram of relative intensity of the modern high explosives, as shown by the results obtained in his experiments, and he draws the following conclusions:

I. The assumption sometimes made that the economic value of a dynamite is simply proportional to the known percentage of nitroglycerine it contains is shown to be erroneous. A judiciously selected base adds enormously to the energy developed by the nitroglycerine alone.

II. There appears to be an advantage in gelatinizing the nitroglycerine before its absorption.

III. The composition of the base is practically as well as theoretically a very important matter. For example, the lower grades of forcite and rendrock, which are very similar in composition, show nearly equal intensity; and the same is true of dynamite No. 2 and Vulcan No. 2; but both grades of electric powder fall far behind these rivals.

IV. It seems to be a general law that with any particular kind of base there is an economic gain in increasing the percentage of nitroglycerine up to a certain point, but that beyond that point the advantage ceases.

* Proc. Nav. Inst. 11, 99.

The instructors in the Department of Ordnance and Gunnery, U. S. Naval Academy, have prepared a work for use in instruction in that department entitled "Textbook of Ordnance and Gunnery," 1884, in which the most modern advancements in the construction and use of ordnance and ammunition are described by the aid of many excellent plates and cuts, while the latest data are discussed according to the most approved methods. The progress in the art of gunnery is so rapid that the best textbooks and treatises soon become imperfect, and it is for the purpose of bringing the instruction into accordance with modern views and methods that this book has been prepared.

A new powder known as the Cocoa powder, and made by the Rottweil-Hamburg Powder Co. at their works at Düneberg, near Hamburg, has been exciting some attention abroad. It is formed into hexagonal prisms, with one canal, and is of the color of cocoa, whence the name. Two pamphlets issued by the firm, dated 1882 and 1883, and entitled "Trials executed with Prismatic Powder," have come to hand, from which we extract the following:

Powder in prisms of 50 mm. was tested in a 21 centimeter gun of 30 calibers length against ordinary prismatic powder. The Cocoa powder is designated as C/82, the ordinary prismatic as C/75. The results are given in the following table:

Powder.		Weight of Projectile Kg.	Muzzle Velocity. M. S.	Pressure of Gas in Atmospheres.		Energy of Projectile.		
Description.	Charge. Kg.			Rodman Gauge.	Crusher Gauge.	Total.	Per Kg. of Powder.	Per Atmosph'e Rodman Gauge.
C/82	39	140	481	1935	1975	1648	42.3	0.85
C/75	39	"	490	2680	2825	1713	43.9	0.64
C/82	42	"	499	2130	2150	1776	42.3	0.83
C/75	40	"	497	2830	2905	1761	44	0.62
C/82	45	"	519	2365	2380	1922	42.7	0.81
C/75	40	"	506	3035	2970	1827	45.7	0.60
C/82	48	96.5	606	2320	2255	1810	37.7	0.80
C/75	42	"	607	3035	3015	1814	43.2	0.60

The above figures show:

1. That the new Düneberg powder, C/82, produces about 700 atmospheres less pressure than the prismatic powder C/75, while the velocity remains the same.

2. That the powder C/82 produces 33 per cent. more energy per atmosphere pressure than C/75.

3. That with the powder C/75, a 21 cm. shell of 3½ calibers length, weighing 140 kg. attains a velocity of 500 metres, only at a comparatively high pressure of gas, whereas the new powder produces velocity at a proportionately low one.

While a charge of 40 kilos of the old pattern may be deemed too great, on account of the high pressure of gas it produces, a charge of the powder C/82 may safely be increased to 48 kilos; the pressure thereby produced, reached according to the Rodman gauge but 2615 atmospheres, according to the crusher gauge but 2570 atmospheres, the muzzle-velocity was 537 metres.

Other properties claimed for the new powder are comparatively little smoke and a slow rate of burning when unconfined. It was especially noticed at the trial that C/82 gave less and thinner smoke than C/75, which is of the greatest importance, as great quantities of dense smoke dispersing slowly may stop the firing, as was recently the case during the bombardment of Alexandria.

A grain of C/82 powder when ignited in air did not explode like C/75 and C/68 powder, but burned slowly, showing a red flame. A closed box containing 55 kg. of C/82 powder was ignited. The powder burned out in about 10 seconds without any detonation (?) whatever. It was found that the screwed lid had been loosened, without however being thrown off the box, and that with the exception of a few slight burnings the lid presented the same appearance as before the experiment. The box also escaped without any damage. This property of burning without explosion is of value in the use of powder. Another feature in the powder is that it attracts moisture less than powder of the old pattern. Experiments made with the 40 centimeter gun of 25 caliber length gave as good results as those above quoted. These experiments were made in 1882.

The pamphlet for 1883 contains data from tests with guns of various sizes. Among them we observe, that in the 28 cm. gun of 35 calibers length, with a projectile weighing 345 kg., 100 kg. of C/82 powder gave a muzzle velocity of 525 metres and a pressure by the Rodman gauge of 2325 atmospheres, and by the crusher gauge 2350 atmospheres. Both pamphlets contain tabulated results of many trials.

It has been tried in Russia in small arms, and in France in large grains, and is reported to have given good results. A resumé of some of the firing trials will be found in the *Revue d'Artill.* **21**, 77 and 475, 1885.

In the *Jour. Roy. United Service Inst.* **28**, 379, 1884, under the subject of "Gunpowder considered as the Spirit of Artillery," Col. Brackenbury, R. A., says that two firms in Germany are making the above mentioned powder, one calling it Cocoa and the other Brown Powder. The proportion of sulphur in its composition is small, and the charcoal, if we may so call it, is different from that generally made. When first brought forward it was irregular in its action, but later samples have given very good results, about the same as Waltham Abbey C_2, and with a less amount of powder. They are prepared to make it at Waltham Abbey if its value is established, but some claimed that its erosive action is too great.

Considerable space is devoted to the subject of blending powders, and cuts are given illustrating the method followed. In this connection he says an idea has lately been set afloat that this process can be got rid of and powder made so regular that it will need no blending, but up to the present time there appears no prospect of any such consummation. Gunpowder is such a nervous and sensitive spirit, that in almost every process of manufacture it changes under our hands as the weather changes. Sometimes its sensibility can be detected and allowed for, as in the process of pressing it into moulds, when we can by actual trial tell what densities we are getting, and give more or less pressure as is required. For instance, on the morning of the 13th June, 1882, the pressure had to be applied for 45 seconds to obtain the required density. Later in the day only 29 seconds were required to obtain the same density, so that in the morning of a June day half as much again time was required as in the afternoon. On the 30th June, 1882, during part of the day the time was as short as 26 seconds; on the 11th December the time varied between 98 and 84 seconds to get the same density as was obtained in June. In the other stages of manufacture we have no such indications as in the pressing process, but it is a fact that not only the warmth of summer and the cold of winter affect it greatly, but the morning mists, the sunshine of midday, the dews of evening, yea, even a passing cloud, tell upon its nervous temperament. As a mitigation of the weather difficulty, they are to try warming a set of houses with warm water.

Under the title "A Flashing Test for Gunpowder," Chas. E. Munroe discusses in the *Jour. Am. Chem. Soc'y*, **6**, 7, 1884, the merits and defects of the method in use as described in the "Ordnance Instruc-

[illegible]

[illegible] Cassel, Germany, [illegible] present State of the [illegible] claimed that the German [illegible] other countries, and are

which this firm supplies, and among them, besides the densimeters, chronographs, pressure gauges, and the like, we especially note an apparatus for measuring the length of cylinders in crusher gauges, which it is claimed will measure a difference of $\frac{1}{40}$ of a millimeter ($\frac{1}{1000}$ of an inch), another for measuring the length of cut in the Rodman method, which will read to the $\frac{1}{100}$ millimeter ($\frac{1}{2500}$ inch), and another still for measuring the thickness of wire and width of mesh in metallic powder sieves, which also reads to the $\frac{1}{100}$ millimeter.

The newspapers for some time past have contained notices of the dynamite gun now on trial at Fort Hamilton. One of the fullest descriptions, with an illustration, is to be found in the *Scientific American* 50, 214, April 5, 1884. This represents the 4-inch gun building at the Delamater Iron Works, N. Y. It consists of a brass tube, 40 feet in length and ¼ inch thick, mounted on a high steel girder. The latter is trunnioned and is pivoted on a cast-iron base, thus enabling it to be swung into any desired position and range. To assist in the latter operation guys are placed on either side of the base, and their length can be altered and fixed by means of hand-wheels.

Compressed air is introduced to the gun from below and passes up through the center of the base, the pipe connecting with one of the trunnions (which are hollow); it is then carried into a pipe at the side of the gun which leads into the valve. This valve is a continuation of the breech of the gun, with which it is connected by a short passage.

An important feature of the system, and one upon which the success of the undertaking greatly depends, is the projectile, or dart. It consists essentially of two parts, and while several different modifications have been tried, the principal features are alike in all of them. The forward part of the dart consists of a thin brass tube, into which the charge of dynamite is inserted. At the rear the tube is enclosed by a wooden plug, which flares out towards the rear until its diameter equals that of the bore of the gun. The forward end of the brass tube shows a mass of some soft material, into which is inserted a pin firmly held in place, the end being closed by a conical metal cap. Provision has also been made to allow a certain amount of air to act as a cushion for the dynamite cartridge, thus lessening the shock due to a sudden discharge. It is therefore claimed, that under ordinary circumstances there is little danger of the charge exploding,

since the pin cannot reach it and ignite the fulminate at its end; but when thrown from the gun, the impact against a body will displace the soft material and drive the pin home, causing an explosion. Another feature of the projectile is the power which it possesses to correct, to a certain extent, the deflection due to a side wind. It will be noted, that with the present construction, the centre of gravity of the dart is some distance forward of its centre of figure. A side wind acting upon the lighter rear part would therefore have the tendency to deflect it so as to turn the head of the dart into the wind, which action would, in a measure, tend to keep it in the line of its trajectory.

The firing of the gun, if the expression may be used, is accomplished in the following manner: The dart is inserted in the breech, and a gas check placed in position; a lever then being moved, the valve is opened and the air pressure admitted. This method of discharge will, it is thought, obviate the danger of the shock, which had heretofore proved a stumbling block to success; and in addition, the valve-controlling mechanism is automatically arranged to admit the air, gently at first to overcome the inertia of the projectile, following with full pressure, and finally closing at the proper time as the dart leaves the gun.

Experiments made thus far have shown that the apparatus can be depended upon for a fair degree of accuracy and rapidity in firing. As regards the range attainable, the two-inch gun now being tested has attained 1¼ miles with a pressure of 420 pounds to the square inch. In the four and six-inch gun which are in course of construction, it is intended to use pressures of 2000 pounds and over, by the use of which they hoped to attain a range of three miles. Advantages claimed for these guns are lightness and ease of manufacture.

The Washington *Sunday Herald* of March 17, 1884, states that the experiments with dynamite shells have proved less efficient than was anticipated, as they have no penetration, and the explosion takes place on striking. The issue of March 30 narrates that a workman at the Delamater Works tried the 4-inch gun with a piece of cotton waste. Although only a 100 pounds pressure was put on, the waste was blown through a wooden door two inches thick, making quite a large breach.

The idea of employing the expansive force of steam, or of compressed air, for propelling projectiles is not a new one, but its application has not heretofore met with success, since penetration

has been sought for. Among other contributions to the subject is a paper "On the Numerical Expression of the Destructive Energy in the Explosions of Steam Boilers, and on its Comparison with the Destructive Energy of Gunpowder," by G. B. Airy, *Phil. Mag.* [4] **26**, 329, 1863. He reaches the conclusion that the destructive energy of one cubic foot of water, at the temperature which produces the pressure of 60 pounds to the square inch, is equal to that of one pound of gunpowder.

In Richardson & Watts' "Chemical Technology," Vol. I, Part IV, page 523, London, 1865, we also find the following: "High pressure steam is exceedingly well adapted to the performance of this kind of work; unluckily it would require high pressure steam of 400 atmospheres or 5000 lbs. pressure on the round inch to perform this duty, and as such steam could only be generated in a furnace intensely heated, it is scarcely probable that boilers will be found sufficiently strong and durable to work continuously under such pressure. If they were found to be practicable, nothing more would be necessary than to bring a steam pipe from the boiler to the breech of every gun in a fortress or a ship, and the admission of the charge of such steam into the chamber by a valve would be sufficient to discharge the missile of the 68-pounder with a speed of 1600 feet a second. The well-known Mr. Perkins studied this subject carefully, but applied it somewhat differently. He found that steam of this pressure could be generated only by water nearly red-hot; and instead of throwing the steam into the breech by a pipe, he threw the red-hot water into the breech of his gun, allowing it when there to expand itself into steam and expend its force in giving speed to the ball. This expedient of Perkins is well worthy of study. It has both the defects and advantages of a gunpowder gun. The red-hot water thrown into the barrel would have the fault of being too powerful at the beginning of its expansion and too weak at the end. The barrel would be filled partly with water and partly with steam; and as the water grew into steam it would lower its temperature and its pressure, so that the explosive force would fall off very much towards the end of the stroke. This is the inevitable evil of allowing the water to become vapor in the gun. When the steam is generated in a separate boiler, and freely admitted into the breech of the gun, there is reservoir enough of heat and steam to maintain the even pressure in following up the ball from the breech to the muzzle. It is the evil of charges converted into gas within the breech of the gun, that their temperature and pressure are too high at starting and too low at the

end. The steam-gun would in this respect be the best of our projectile forces.

"Compressed air has many of the advantages and some of the defects of steam; and the frequent use of the air-gun has shown its convenience as well as its efficiency. Air can be compressed into a reservoir by mechanical force, just as steam can be raised in a boiler by heat; and by compressing 400 times the natural quantity of air into a given space, a pressure of 400 atmospheres might possibly be obtained in this way. If an air pipe communicated from this reservoir to the breech of our gun, air of 400 atmospheres of pressure would certainly be able to follow up the 68-pounder shot, with pressure and velocity able to discharge it with a speed of 1600 feet per second, and, therefore, to do our work; but the apparatus would be full of mechanical difficulties.

"Liquid gases are known to be receptacles of enormous mechanical power. Carbonic acid gas, liquefied and shut up in a reservoir, generates large volumes of gas with great rapidity the moment it is permitted to expand. Other gases expand with still greater rapidity and force; and if we could conceive liquid gases to be easily made, safely carried, and comfortably handled, a charge of liquid gas bottled up in the breech of a gun would be a very effectual propelling power, and quite able to generate the force we want, and to apply it within the time we require. This system, however, is also beset with mechanical difficulties.

"The preceding illustrations of steam, compressed air, and liquid gases lead us on very instructively to the manner in which fire has become necessary to do the work of a gun. A supply of heat is essential to the expansion of a gas, and a rapid supply is indispensable to the rapid performance of the work. In steam, the fire is not only external to the gun, but external to the boiler in which the steam is generated. In gunpowder, the fire is introduced into the inside of the gun, for the purpose of supplying the heat that is wanted to raise the gases to their elastic pressure, and to maintain them at that pressure while expanding. Red-hot steam introduced into the breech of a gun rapidly cools down and loses its heat and power in expanding. If we could introduce fire into the breech of the gun at the same time, to maintain the heat of the steam and the water, the steam would become an admirable propelling force. Carbonic acid gas expanding rapidly from the liquid into the gaseous state cools down so suddenly as not only to lose its mechanical power, but to

freeze into solid flakes of snow. If we could charge the breech of the gun with fire as well as with liquid gas, the fire would give it the heat it wants, prevent its congelation and maintain its power to the end of the discharge. What gunpowder and gun-cotton do is really to provide a reservoir of gas and a fire to heat it simultaneously and in the same chamber. In the case of gunpowder the fire is fed with charcoal, in the case of gun-cotton the fire is fed with gun-cotton wool—another form of carbon. In gunpowder, large quantities of carbonic acid gas are generated, possibly in the liquid state, and are heated by the internal furnace of the charge, possibly red-hot. In like manner in a gun-cotton charge, red-hot water or steam is introduced with other gases, possibly also liquids, together with an internal furnace of flame; and thus the work is done—first, by the release of the gases themselves, and, secondly, by the continuance of the elasticity of those gases by the internal supply of heat. This is how gunpowder and gun-cotton really do the work of a steam-gun, a carbonic acid gun, or any other kind of gas gun."

Prof. R. H. Thurston treats of the same subject in the *Jour. Frank. Inst.* **88**, 427, December 1884, under the title "Steam Boilers as Magazines of Explosive Energy," and after referring to the above mentioned paper of Airy's, and that of Rankine "On the Expansive Energy of Heated Water," *Phil. Mag.* [4] **26**, 1863, he has computed, by the aid of the formulas of Rankine and Clausius, the magnitude of the quantities of energy residing in available form in both steam and water, for the whole usual range of temperatures and pressures familiar to the engineer, and also for those beyond, which have only been attained experimentally, but which are likely to be reached in the course of time, and he has plotted curves of the available energy of heated water, of latent heat and of steam, and the explosive energy of many different forms of boilers.

The dynamite air-gun is also described with illustrations, and discussed by Chas. E. Munroe in *Van Nostrand's Eng. Mag,* **32**, 1, January, 1885, in a paper entitled "Some Recent Experiments on the Use of High Explosives for War Purposes."

In determining the efficiency of the air-gun projectile against an armor-clad vessel, the author assumes that one of four effects may be produced, depending on the resistance of the armor to penetration, and on the material, thickness of wall, profile, weight and velocity of the projectile.

(1). The projectile may either penetrate the armor partially and explode in place, or pierce it completely and burst inside of the ship. This is the condition of greatest efficiency.

(2). It may explode immediately upon impact, and before breaking up. Then the explosive will exert the energy which it develops through explosion in a resisting receptacle.

(3). It may rebound before exploding. Then the effect will be reduced by the interposed cushion of air.

(4). It may break up on impact before the explosion takes place. Then the energy of the explosive will be simply that which it develops when exploded unconfined.

The resistance of an armor to penetration depends upon its hardness, its tensile strength (that due to bolting as well as that inherent in the metal itself), and its inertia. The latter is augmented by the thickness and weight of the armor, and by the rigid system of bracing which now obtains in practice. How great this resistance is can best be illustrated by an example. While, from the fact that very rapid progress is being made in the improvement of armor plates, we may have not chosen the best example, let us take the steel plates designed for the Furieux. One of these, weighing 23 tons, 9 cwt., and averaging over 17 inches in thickness, was tested at Gâvre, July 13, 1883. Three shots were fired against this plate from a 12.6-inch rifle using chilled iron projectiles, weighing 759 pounds each. The first and second shot struck with a velocity of 1403 feet each. The third struck with a velocity of 1438 feet. The projectiles were all broken up, all of the twenty bolts through the plate remained intact, and no portion of the plate fell from the backing, although it was somewhat indented and cracked.

Although we are not yet informed concerning the air-gun projectile, except for the weight given above and the pressure of the air also cited, yet when we remember that in the Gâvre experiments the pressure of the powder gas probably approached 40,000 pounds to the square inch, it is not unfair to infer that with a pressure of 500 pounds to the square inch a projectile will possess little or no penetrative power against the Furieux plates at a distance of 1¼ mile. Whether then the projectile would explode on impact or after rebounding, or whether it would break up before exploding, is a matter for speculation and conjecture. If the last condition prevails, then we can judge from some experiments recently made at the Naval Experimental Battery, what the destructive effect would probably be.

In these experiments Commander Folger detonated upwards of 400 pounds of dynamite, in charges of from 5 to 100 pounds, against a wrought-iron target, eleven inches thick, without damaging the plates. These charges were enclosed in cartridge bags and suspended against the plates. Commander Folger concludes from these experiments "that it is a matter which hardly admits of doubt, that a modern armor-clad will not be materially injured by the explosion, in superficial contact with her over-water plating, of charges of more than 100 pounds of dynamite."

Admiral Courbet, we must add 2 torpedo boats, 27 metres long (88 ft. 6½ inches), whose action against the Chinese light squadron might be very efficacious and even decisive. Finally, a quarter of an hour after firing began, the ironclad Triomphante, kept at a considerable distance from the principal theatre of the struggle by her draught, nevertheless gave to our squadron the support of her 6 24 c. guns (9.44 inches).

Commanded by a chief who knew how to inspire them with absolute confidence, our sailors are filled with ardor. The greater part of them already have spent many months on board their vessels. They know their officers, to whom they are attached by the thousand ties created by a long voyage, perils faced, success conquered, as well as reverses encountered together. Well versed in all exercises aboard ship, nevertheless they were compelled to supplement them on account of the absence of all land force. Even counting several detachments drawn from the vessels outside the Min River, Admiral Courbet could not land more than 600 or 700 men, of whom many doubtless had neither the time nor the opportunity for complete military instruction looking to such an undertaking.

The Chinese flotilla in the Min River consisted of 11 vessels, cruisers, transports, despatch boats, and gunboats, carrying altogether 56 guns, 2 of 25 c. (9.84 inches), throwing shell or shot of 185 kilogr. (411.4 lbs.); 1 of 20 c. (7.87 inches), throwing an 82 kilogr. projectile (180.4 lbs.); 2 of 18 c. (7.09 inches), projectile 53 kilogr. (116.6 lbs.); some of 16 c. or 15 c. (6.3 or 5.91 inches); and finally, about 30 Vavasseur guns of 13 c. (5.12 inches), throwing 25 kilogr. (55 lbs.) projectiles. All the Chinese ships are wooden, without armor; of elegant appearance, but light build. Their hulls are more or less protected against sinking by water-tight bulkheads. The displacement of the largest and smallest respectively, 1400 and 250 tons. Their very numerous crews are without revolving cannon or mitrailleuses, but they have muskets and other small arms of perfect model. If you add to these 11 ships 9 war junks, each possessing a middling armament of small calibre smoothbores, two other very large junks filled with soldiers, and carrying 2 or 3 cannons, 7 ordinary steam launches and 3 or 4 row-boats, all carrying in the bow spar torpedoes, you will have the total of the naval force opposed to the French squadron.

This force is supported not only by a numerous infantry established in the neighborhood of the Foo-Chow arsenal, but also by

6 or 7 batteries, of which 2 are each armed with 3 Krupp guns of rather feeble calibre, but which can do much injury to our ships.

Truly, Chinese troops and Chinese crews are worth little, if one compares them with analogous forces of any European power. Still one must guard against completely despising them. They are no longer the undisciplined soldiers without experience or military disposition, firm enough behind good walls, but worthless, or nearly so, in the open field, that were opposed to our troops during the campaigns from 1857 to 1860; still less are they the grotesque combatants so rudely handled by the English from 1840 to 1842. They will be seen before the fight, provoking our sailors, according to the fashion of Homer's heroes, by cries and insults. This is not entirely a vain boast. Most of these men are brave, they will give many proofs of it. Many had received their military instruction under European officers; they can move in unison, fire by command, and intelligently perform skirmish drill. Happily for us, their leaders are worse than poor; their artillerists, with a few exceptions, as unskilful as formerly.

After having indicated the number and the nature of the forces present, let us show how they were distributed and arranged before the fight. To understand this it will be necessary only to glance at the accompanying sketch.

Our squadron had been in the Min River for a month, from day to day waiting for the order to begin hostilities. The dispositions for action had been made. The Chinese vessels attentively watched and imitated the movements of ours. One can comprehend how trying this situation was, how enervating even for our crews, whom the enemy could attempt to surprise by an unexpected attack, who saw accumulating every day abreast of our ships and behind them, junks, fire-ships, land batteries and infantry. The Chinese hoped the French squadron never would be able to get out of the Min River. Knowing well the evening before that we would open fire August 23d, from the morning of that day they do not spare us hostile demonstrations. The ships of the two nations are riding to the flood under steam, ready for combat. During several hours the situation of the Volta and our three gunboats, all four anchored above Pagoda Point, was critical. For, in case the Chinese took the initiative, the three vessels anchored below the Pagoda, near the Duguay-Trouin, the Villars and the d'Estaing, could get under way without noise, the current would carry them quickly abreast of the

port (starboard?) side of the Volta and our gunboats, where our large cruisers, stopped by their draught of water, could not follow them. Fired upon on one side by three ships, on the other by the junks and land batteries, and attacked in the rear by Chinese ships stationed above, the Volta, the Aspic, the Vipère and the Lynx can be overwhelmed by a crushing force. Happily, nothing of this kind takes place, and the tide turns ebb. We are going to have the double advantage of position and of the offensive. From this time the Chinese fleet is doomed. At the very outset the three fine ships imprudently left below exposed to the fire of our large cruisers will be rendered in a few moments motionless and *hors de combat.* Two other vessels, despatch boats and transports, each carrying four cannon, are secured to the quays of the Foo-Chow arsenal; they do not count in the action. Aided by our two torpedo boats, sustained against the shore batteries and the junks by the artillery of our large cruisers, the Volta, the Aspic, the Vipère and the Lynx have every chance to overcome the six other Chinese vessels.

II.

It is 1.45 P. M. At a signal from the Admiral our two torpedo boats are directed at moderate speed against the enemy. No. 46 against the cruiser Yang-Woo, 1400 tons, the largest Chinese vessel; No. 45 against the transport Foo-Poo, 1258 tons. The torpedo boats were about 300 and 500 metres respectively from their objective. The torpedoes are charged with 12 or 14 kilogr. of gun-cotton. On account of the current, the torpedo boats, following the course necessary for attack, cannot reach the enemy for about one minute and a half. Our squadron has opened fire, but the Chinese vessels, although on their guard, have no time to discharge a single projectile at the torpedo boats. Perhaps having already slipped, they are also without speed.

No. 46 exploded her torpedo by contact against the Yang-Woo's port side amidships. Injured beyond remedy, but still able to use her engine, she headed quickly towards the bank, where she ran aground. The torpedo boat got clear without difficulty and began to retire. Just at this moment a small shot or a canister shot pierced the boiler. This accident caused no direct loss, as the crew rushed on deck, but one of the men was killed there by a musket ball. Carried by the current, No. 46 soon was sheltered from further injury.

Her torpedo spar was bent so that the two parts formed an angle between them of about 90°.

Less successful in her attack, drifted by the tide, No. 45 only reached the port quarter of the Foo-Poo. She struck the Foo-Poo at full speed, and only began to back at the moment contact produced the explosion. Her fir buffer was broken completely, but the hull was uninjured. The explosion bent the torpedo spar at the point of junction of the two parts so that they formed an angle of about 130°, yet the short staff and the forked portion were almost intact; although yielding to the action of the current, No. 45 is checked and held to the Foo-Poo's stern by the short staff and the fork, which probably have fouled the screw of the Chinese vessel. In vain she backs, the critical situation continues and may cause her loss.

Struck beneath the fleeing forms on her decks, the Foo-Poo was preserved from immediately sinking by the thickness of her heavy stern and by her water-tight bulkheads. Roused from their stupor, the crew opens a heavy musketry fire upon No. 45; besides they throw shells upon her decks, and probably hand grenades also, which happily do not explode. Backing producing no result, the captain of No. 45 reversed the engine, which immediately disengages his vessel. It is at this time he is struck in the eye by a bullet and one of the crew is wounded in the arm.* Nevertheless, he retains command and superintends the vessel's retreat, and she, followed for a few moments by the Chinamen's bullets, is soon out of danger.

In short, the success of our torpedo boats is complete: for, even though the Foo-Poo was not injured as badly as the Yang-Woo, nevertheless she was injured so badly as to be unable to prolong her resistance. It is now necessary to examine under what conditions this success was obtained. We must notice that this is the first case of concerted action between torpedo boats and ships, and otherwise

* The sheet-iron dome that protects the captain and the steersman of a torpedo boat is, as is well known, pierced with little glass windows that can be opened or shut at pleasure. In order to diminish these openings when not closed by the glass, the captain of No. 45, Mr. Latour, had fitted over each of them a little steel mask, that, by means of a hinge and a screw, could cover the opening or remain raised like a screen. Lowered, this mask completely covered the window opening, but itself showed a slit only 12 c. (4.72 inches) long and 1 c. (.39 inch) wide, through which the captain peered. Very probably, the bullet to which Mr. Latour owes the loss of an eye penetrated in ricochetting through this little slit.

than by surprise. Even in the two attacks in broad daylight on the Danube against a Turkish monitor, by Russian torpedo launches, they tried to hide themselves behind the islands, the points, or the reeds in the river. Entirely different is the character of the action of August 23, 1884. Our torpedo boats operated as above in broad daylight, but more than that, against a forewarned enemy; a circumstance that in presence of adroit adversaries, vigilant, well armed and prepared, is the most unfavorable for the assailant. In the present case, on the contrary, no serious consequences resulted from this. Our torpedo boats, that had the good luck to be able to take post 400 metres (¼ mile) from the enemy, crossed this distance before the Chinese had the idea, the time, or the possibility to fire a projectile, not even a bullet at them. They thus reached stationary ships, without revolving cannon or mitrailleuses, unprotected by any exterior defence; neither counter torpedo boats, nor floating stockades, nor nets. Only one thing could interfere with the attack, the force of the current, which is probably from 3 to 4 knots. Note, however, that this current singularly aids their retreat when shrouded in thick smoke, and covered by the fire of our squadron, so superior from the beginning to that of the Chinese.

One must not be deceived regarding an attack in every way favored, except by daylight; one must be careful not to believe that a similar *coup de main* could be attempted against any other than the Chinese navy. Two torpedo boats attempting such a thing under similar conditions, would be riddled by small shells, grape, and canister, before attaining their objective.

A question naturally suggests itself here: could boats discharging torpedoes have been able to attack the Chinese ships, August 23, with equal or superior chances of success to those of spar torpedo boats? We do not hesitate to reply in the negative. Examine the subjoined sketch. The spar torpedo boats reached the Yang-Woo and the Foo-Poo while steering, during the attack, in the dead angle astern of these ships, so as to avoid their artillery fire; it was only at the last moment they manœuvred to describe the curve that enabled them, under favorable circumstances, to strike the enemy's bilge. A boat discharging torpedoes, obliged to place herself bows on, 100 or 200 metres forward of the beam of the vessel attacked, because it is necessary to allow for a strong current, would have been compelled necessarily to traverse twice as long a distance; besides it would have been compelled to leave the dead angle of the Chinese guns much

sooner. Rallying from the first moment of surprise, the enemy would have had one or two minutes in which to point his guns, and who knows but that a shot fired at a range of from 200 to 400 metres (219 to 437 yards) would not have rendered the torpedo boat unserviceable? In any case, she would be exposed during the first part of her escape, to these dangers.

However, let us suppose the discharger preserved from all harm during her offensive movement. Can one believe that the Whitehead or even the two Whiteheads discharged by her, across a 4 knot current, with all the pointing errors that can happen during the smoke and excitement of battle, with all the causes of deviation to which these engines are liable by the method of their use, the nature of their construction, and their low velocity considered as projectiles; can one believe these two Whiteheads would have had the surety of action of a simple torpedo carried by the boat itself directly to the enemy's side? And even if their "direction-pointing" was excellent, could they not pass easily, being regulated for 3 metres (9 feet 10 inches) of immersion, under the keels of the Chinese vessels, of which several should not have had a greater draught than this 3 metres? In the absence of attempts at an anchorage, crowned with incontestable success, but discussed, prepared, studied and executed in a liberal spirit, with chosen machines, maintained and regulated as in a physical laboratory; in the absence of these attempts, we do not think the affirmative can be sustained.

III.

We said the Chinese had prepared a certain number of torpedo launches. These small craft, prodigal of empty demonstrations against our ships before the opening of hostilities, did not even appear during the action. However, Admiral Courbet had taken precautions against them. Our steam launches were armed, and were to prevent them from approaching the larger vessels. Manifestly, under these circumstances, they were to perform the duty of "counter torpedo boats." It will not be useless to state this in view of certain writings, in which the idea of thus protecting ships against attacks by torpedo boats is rejected from the very outset as not worthy of discussion. During the blockade of Callao, the Chilian ships and the Peruvians, their adversaries, protected themselves by means of steam launches against the attacks of the enemy's torpedo boats. An

encounter between these boats resulted, and two of those engaged, one of each party, were sunk. The measures taken in this respect by Admiral Courbet seem to show to practical minds that the creation of a special fleet of "counter torpedo boats" is already a fixed idea. What our ordinary steam launches could do against similar craft only, truly swift boats, provided with a photo-electric apparatus, armed with revolving cannon, with hand torpedoes, etc., would be able to do against speedy torpedo boats.

After the naval engagement of the 23d August our steam launches pursued the Chinese torpedo boats and rendered many of them unfit for service. Several of them, however, reappeared during the two following nights and disturbed those of our ships below Pagoda Point. Notably the 25th, at 4 o'clock in the morning, two of them attempted a surprise. The first steered for the Vipère, anchored at the head of the French line; her torpedo spar rigged for attack. Seen by one of that ship's sentries, who fired his musket at her, she changed course to reach the Duguay-Trouin.

Alone of our vessels present at the Pagoda anchorage—at least so we believe—this large cruiser and the ironclad Triomphante were furnished with photo-electric apparati. Thanks to the luminous rays of these apparati, the Vipère was enabled to point her Hotchkiss guns with so much celerity and precision that she sank the Chinese boat in the twinkling of an eye. As for the second torpedo launch, she was discovered as well and followed by the electric lights. Her crew had barely time to abandon her before she met the same fate as the first.*

This fact, of but little importance in itself, is, however, of great interest at the present time. Has it not been written that "large vessels will seek in vain to obtain light by means of the electric light," to defend themselves against torpedo boats, that "whoever has seen this light employed aboard ship easily will be convinced that it interferes with our powers of vision more than it aids them, while at the same time it indicates with certainty to the enemy's torpedo boat the position of its mark"; that after having discussed "in every navy the question whether revolving cannon will render torpedo boats *hors de combat*, they have answered it, nearly everywhere, in the negative"?† The prompt destruction of two Chinese torpedo

* Report of the captain of the Vipère.

† Les torpilleurs autonomes et l'avenir de la marine. Automatic torpedo boats and the future of the navy. By M. Gabriel Charmes, pp. 21, 50, 45, etc.

launches, by our revolving cannon, aided by the electric light, shows how exaggerated, one even might say how manifestly erroneous, these statements are. We know well the Chinese torpedo launches were slow and badly handled—in a word, resembling in no sense real torpedo boats; the attack was, therefore, under conditions very inferior to the defence. Nevertheless, the defence did not make use of all the means that can be used to-day by an ironclad squadron at anchor. Our eight vessels had only two electric light apparati to illumine all the approaches; all will agree these were few. They were not protected by any exterior defence. Their crews, fatigued by two days' fighting and a night of terrible anxiety, which was, using Admiral Courbet's expression, "a continual qui-vive"; their crews paid but little attention to this tardy alarm, on the morning of the 25th at the close of a second night that had been passed, up to this time, in perfect calm. Yet, thanks to the electric light and revolving cannon, the Chinese torpedo boats did not have even the time seriously to menace our vessels. Certainly the clear rays thrown by one around its centre, and the hail of little shell thrown by the other, will not suffice always to protect one or more vessels against the attack of numerous swift and well-handled torpedo boats. But it is permitted to affirm that often they will contribute powerfully towards obtaining this result.

IV.

The 23d, at 1.45 P. M., at the same time that the torpedo boats Nos. 45 and 46 were moving rapidly upon the Foo-Poo and the Yang-Woo, our vessels opened fire all along the line. It is only necessary to read Admiral Courbet's report and to glance at the subjoined sketch to acquaint oneself with the situation at the beginning of the combat. The Volta, as well as the gunboats Aspic, Vipère and Lynx, are underway. Their crews are reinforced by detachments from the ironclad La Galissonnière, outside the Min.

"The Volta, while sustaining the attack of the torpedo boats with her port battery and musketry, is to open fire to starboard upon the war junks, her principal mark. At the same time the Aspic, the Vipère and the Lynx leaving the Volta to starboard, will steam rapidly as far as the arsenal and engage the three gunboats and the three transport and despatch vessels there. . . . . The Duguay-Trouin, the Villars and the d'Estaing are to reduce the three vessels

anchored near them with one battery and enfilade the junks with the other. . . . . This plan is executed with perfect accord."*

While passing the war junks, anchored near the shore between Pagoda Point and the arsenal, our gunboats can give them two or three broadsides. The captains of the guns kept them trained until fire was opened, the indicated distances are mathematically exact, so that our first shots struck the enemy with great precision. The Chinese replied with a hail of projectiles, happily nearly all badly directed. It is almost calm, and after a few minutes a thick smoke covers the scene of battle. Our gunboats and armed launches are engaged in a sort of mêlée with the Chinese vessels above Pagoda Point. These slipped their cables and bore themselves well. It is no longer at one, or even several cables length, it is at 100 metres, 50, finally at point blank, that they fight. Mortally injured by the torpedo of No. 46, the Yang-Woo, as we have stated, already makes for the shore. She receives several shell that hasten her loss. Our armed launches after having pursued vainly some of the enemy's torpedo launches, return towards the Chinese vessels; they surround the Foo-Poo, badly injured as is known by No. 45, carry her by boarding without much difficulty, and proceed to run her aground below the anchorage, where she fills. The alphabetical gunboats, Foo-Flug and Kien-Tching, tried to resist. Several well directed shell from our vessels promptly produce results. You see them from this moment straying as though infatuated about the battlefield.

All this took place in less than half an hour. The firing stopped almost entirely on both sides and the smoke dissipates. This is the spectacle the river presents; the war junks anchored between Pagoda Point and the arsenal are burning and sinking. The Volta's shells on the one side, those of the Duguay Trouin, the Villars and the d'Estaing on the other, have torn them to pieces, yet the brave crews of two or three of them still strive to resist. The two large junks anchored the other side of the river, and filled with soldiers with a view to attempt to board our vessels, struck by the shell of our gunboats, are afire. In a few minutes, as one might have expected, the three Chinese ships under the guns of our large cruisers were silenced. Set on fire by our shells, drifted by the ebb, they soon ran aground and sank some miles below. This is also the fate of the two alphabetical gunboats. The flames devoured the grounded Yang-Woo.

*Admiral Courbet's official report of the combats in the Min River.

As for the two transports secured to the arsenal quays, they were abandoned by their crews; the shells from our gunboats soon burn one and blow up the other. Two little Chinese vessels only, thanks to their light draught, are able to ascend the river and escape pursuit, but they bear on their sides serious injuries; they will not long delay running aground and filling.

The river is covered with men and wreck, 22 vessels destroyed, including the war junks, 5 captains that commanded the gunboats or the transports, 39 officers, and 2000 sailors or soldiers killed; these are the losses that this affair costs the Chinese navy. Ours are insignificant alongside such figures. Besides, they result more from the shore batteries than from the enemy's ships. Yet the guns of the latter handled by experienced men would have been formidable.

Thus, the effect of our fire was most astounding. To obtain this result our gunners pointed low. What above all strikes our officers when the smoke is dissipated? Plainly the water has swallowed up the hulls of several Chinese vessels, the very natural result of low-pointed fire, only with 14 c. guns against light hulls. But, at the same time, flames are rising all over the battlefield, showing that our shells set the upper-works of the enemy's vessels on fire with a rapidity, intensity and multiplicity of effect truly terrible. This is what struck our officers; almost astonished them. It furnishes a lesson not to be overlooked. Besides, it is a confirmation of the truth, proved already by several episodes of the American war of Secession, by the burning of the Schwartzenberg at Heligoland, of the Palestro at Lissa, that in presence of the effect of existing artillery, wood should be eradicated as quickly as possible from the construction of fighting ships. But this is not all.

Examine the results of some of the actions of the past 20 years. In spite of the advent of the ram and the torpedo, the gun still holds the first place in these actions. In what way does it principally make its action felt? Is it by causing at or near the water-line, breaches through which the water can enter and sink the enemy's ship? Very rarely, and only when the hull struck is light, like that of the Federal gunboat Hatteras sunk by the Alabama, or that of the same Alabama sunk later by the Kearsarge. No, when it is not fire, it is the injury caused the upper-works, the essential parts, the steering gear, the engine, the boilers, or the personnel itself of the attacked vessel, that nearly always shows the power of the gun. Why, during the war of Secession, was the ram Atlanta obliged to strike to the monitor

Weehawken, the ram Tennessee to surrender to Admiral Farragut's monitors and corvettes? Because the large 23 (9-inch), 28 (11-inch) and 38 (15-inch) c. smoothbores of the Federal ships pierced the armored redoubt of the Atlanta and destroyed the shelter of her pilots, carried away the smoke-pipe of the Tennessee, injured her rudder, and rendered many of their crews *hors de combat.* At the same time these vessels were in no danger of sinking. The same regarding the Huascar after her celebrated fight with the Cochrane and the Blanco. When the Peruvian vessel struck, her under-water body was intact, but her guns were dismounted, her turret ruined, the armor of her freeboard pierced and broken in many places; the Chilian shells had demolished the internal arrangements, had injured the steering apparatus, had killed nearly all the Huascar's officers, and had rendered half the crew *hors de combat.* And the Bouvet, after her encounter with the Meteor? And the Turkish ironclad Athar-Chefket, during her chase of the Russian steamer Vesta? It was projectiles striking above water certain badly protected parts of their evaporating apparatus, that robbed our vessel of all the benefits of a first success, that obliged the Ottoman to sheer off from an adversary over which she seemed to possess a crushing superiority of force.

Hence the terrible effect of our guns upon the Chinese ships during the Foo-Chow combat brings another proof in favor of this already demonstrated truth: that the gun is more to be feared for the injury it produces above water than for the possible destruction of "floatability." For this floatability is measured more to-day by the two new arms at the service of fighting ships: the ram and the torpedo. Against these the cuirass is absolutely powerless. Besides, this remains the only efficacious protection of the personnel of the ship above the water-line, of the guns, of the apparatus for discharging torpedoes, against the destruction by artillery and also against possible conflagration from shells. On the other hand, the floatability of a vessel has already obtained a partially efficacious protection, and probably each day will obtain more, against torpedo explosions, against the ram, and against artillery itself, in the multiplicity of water-tight bulkheads, and in a well-combined cellular or alveole system. The evident conclusion to be drawn from the preceding facts is that armor, still useful, and perhaps now more so than ever, to give to the upper parts of the real fighting ship—not absolute invulnerability, a desideratum impossible to realize—but a rational, efficacious

protection, at least, against light and medium calibres; armor should be abandoned from henceforth as a method of defence for squadron ships, at and below the water-line. We have seen this idea already put in practical use in the construction of several large foreign vessels, particularly of the Italia and of the Lepanto.*

V.

Up to this time we have only examined the acts of our squadron against the Chinese vessels stationed in the Min River. Their destruction was not the most delicate task imposed upon our ships. It was necessary that they should silence and dismantle, as much as possible, first, the batteries that protected the Foo-Chow arsenal, then in succession all the works echeloned along the river, which had to be descended for 12 miles. In two places the Min narrows so as not to be, between its banks, more than 400 or 500 metres (about 500 yards). These two passes, known by the names of Mingan and Kimpai, present certain difficulties of navigation, and are commanded by heights favorable for their defence. The Chinese had not neglected these advantages. Happily for us, the batteries they had erected, some time before our ships had entered the Min, were constructed more with the idea of repelling the attack of an ascending squadron. It resulted from this that vessels like ours descending it, were able almost always to station themselves so as to take the batteries in reverse or at least diagonally. After our arrival, the enemy, it is true, threw up new works and placed some new pieces in position. He did not have the time nor, perhaps, the means to create obstacles capable of stopping our naval force. Nevertheless, a numerous infantry was in readiness to sustain and protect the two passes. We shall have to settle with them when the time of attack comes.

The same day of the destruction of the Chinese vessels, August 23, our ships silenced the works defending the Foo-Chow arsenal. Only the Krupp battery in the Chinese camp upon a neighboring height had causedthem any loss or sensible damage. Next morning the arsenal was shelled by the Volta and the gunboats, as their draught would not permit the large cruisers to ascend the river thus far.

* See on this subject, *La Marine de guerre et son avenir, cuirassés et torpilleurs.* (The war navy and its future, ironclads and torpedo boats). By Mr. Grugeard, Ex-Minister of the Navy (pp. 46 and others).

"During the afternoon our 28 kilogramme (61.6 lbs.) shells demolished everything not beyond their reach. Fire directed upon the workshops and storehouses, and upon a cruiser under construction, did much harm, but not as much as I wished. With the 14 c. calibre nothing more could be done.

"The foundry, the fitting shop, the pattern shop are much injured; the hull of the cruiser is riddled everywhere, etc. But to destroy the arsenal, it was not sufficient to fire a lot of shell of the same calibre into it; the 24 c. (9.44 in.) or at least the 19 c. (7.45 in.) was needed, that is to say, it was necessary to bring the Triomphante or the Duguay-Trouin within range."*

Hence this is well understood. Simply to demolish an arsenal, knock down and burn its storehouses, its workshops, damage its docks, render its floating stock unfit for use, etc., even long ranged, small calibre guns are not sufficient, large calibre is necessary, "at least 19 c."

On the 25th our squadron begins the attack upon the Mingan pass. At this pass there is a series of works, of which the greater part, already noticed, fortunately can be taken in reverse or diagonally by our fire. Five or six of the Chinese batteries are casemated, one of them is armed with a 21 c. (8.26 in.) Armstrong gun enfilading the Mingan pass; another is armored with 15 thicknesses of sheet-iron, each 2 c. thick (total 11.81 in.), solidly bolted together. Plainly, 14 c. guns are powerless against such defences. Hence during the two days of our squadron's operations in the Mingan pass, the vessels thus armed (14 c.), protect our landing parties, throw shell among the Chinese infantry, finish the great task accomplished by the heavier calibres. Thus, to the Duguay-Trouin with her 19 c's, and to the Triomphante with her 24 c's, fell almost entirely the task of dismantling the Chinese batteries, and, in spite of the limited number of heavy guns these vessels carried, they acquitted themselves capitally.

The 27th, 28th and 29th of August, the same tactics against the Kimpai Pass. Here we find, among other works, two batteries of recently built 14 c. guns that enfiladed the pass, a battery armored with 15 c. plates and barbette guns, among which a 21 c. Krupp commanded the entire outside of the pass. While the vessels armed with the 14 c. guns covered the Chinese camps with shells, the Duguay-Trouin and the Triomphante, in spite of certain difficulties of

*Admiral Courbet's report.

navigation, due to their deep draught, silence and ruin the two 14 c. batteries, make large breaches in the ironclad work and in the casemated battery of Fort White, as well as dismount all the barbette guns in the vicinity, among them the 21 c. Krupp, finally protect the exit from the Min River of the rest of the squadron, by dismounting the last Chinese pieces that could disturb them.

Therefore, the indispensable services rendered during all these operations by the large calibres of the Duguay-Trouin and the Triomphante show out plainly in Admiral Courbet's so clear and so exact report. Without their assistance our vessels armed with the 14 c. gun would not have been able to demolish the Chinese works, would have suffered great loss passing their fire. Who can say that one of them at least might not have been rendered *hors de combat*, sunk or burnt after an injury to the engine that rendered her motionless under the enemy's guns? How has it been possible to invoke facts so clearly defined to assist this thesis: that gunboats, ships armed with small calibres and of light build, are capable of rendering the same service in similar operations as ironclads or cruisers carrying heavy guns?*

It is that people wish, systematically, to show the uselessness of ironclads, even for a coast war, and this is what is said: In the future they will avoid attacking batteries and the enemy's strong maritime places; they will reserve their ammunition to riddle with projectiles, open cities, commercial ports, undefended places.† Indeed, leaving out of the question every philanthropic consideration, nothing could be more dangerous than such a system of warfare; above all, against a neighboring power, at the same time continental and maritime. Suppose that even while master of the sea you are beaten on land, that your national soil is invaded. At the first hostile act against his commercial ports the enemy will retaliate by harsh and easily made reprisals, by pillaging and by burning those of your cities that he occupies, and by ruining everywhere your territory. And should he attack, by land, your strong coast defences, is it with unarmed gunboats carrying light-calibred guns that you will assist those besieged? Why, even a battery of field-pieces, sheltered behind an entrenchment, will suffice to keep these gunboats at a distance, whose too feeble projectiles, either near or at a distance, will have no effect, or but very little, upon the besiegers' parallels.

*Les torpilleurs autonomes et l'avenir de la marine. By M. Gabriel Charmes, p. 156. †*Id.*

The operations of the Rolf-Krake during the Duchies' war of 1864, on the other hand, give a fair idea of the services a small, light-draught ironclad can render in coast defence. Always isolated, and having only a battery of insufficient range and calibre—four 20 c. (7.87 in.) smoothbores—this little monitor was a continual thorn in the side to the German troops, who were compelled to construct batteries, establish stockades and lines of torpedoes, solely to guard against her. One saw, in spite of this, the Rolf-Krake now and then braving the concentrated fire of 20 or 30 siege guns, destroy bridges, sink boats full of troops, routing whole battalions, and thus contributing powerfully to the defence of Duppel. Can one think that even several unarmored gunboats could have performed similar service? The German artillery would have soon rendered them *hors de combat.*

Now, suppose that while master of the sea you are equally victorious on the land. Having nothing to fear from immediate reprisals, you bombard "open cities, commercial ports, undefended places," upon the enemy's coasts. Here there is no need of armor, but the same necessity exists for heavy guns, since they are indispensable to destroy "even workshops, storehouses, vessels building," or a fleet. This Admiral Courbet plainly has written, and doubtless no one will reject his testimony.

Really, will you be able to confine your maritime operations to this war of destruction that offers not the slightest danger to your ships? If your land forces besiege one of the enemy's military ports, defended by numerous and strong batteries, are these same vessels to remain as well calm as powerless spectators of the struggle? If by forcing a pass they can take in reverse works whose fire decimates and arrests your troops, will they neglect to aid them with a support possibly decisive?

The American war of Secession, and the Paraguayan war, present incessant examples of this precious co-operation of fleets with armies. But some will say, it was with wooden ships Admiral Farragut cleared the passes at New Orleans and at Vicksburg. Yes, in default of ironclads, corvettes and large gunboats, led by a chief whose talents approached to genius, were able to carry out brilliant strokes against works at the time incomplete and not of much account in comparison with the forts that to-day defend great military posts. Even then they were accomplished only at the cost of much injury and serious loss. At Port Hudson, Farragut was able to get only two ships past the Confederate batteries. The others were compelled

to retire and one of them was destroyed. The great work and the lengthy operations at Charleston, at Fort Fisher, at Mobile, and on the Mississippi, necessitated the employment of light draught iron-clads, whose powerful artillery—generally 28 to 38 c. smothbores—fighting at close range, overturned the most solid of the enemy's fortifications and dismounted his guns. During the passage of an ironclad Brazilian squadron under the batteries of Humaita, a coast-guarder was struck by 96 projectiles and a little monitor of 340 tons by 200! Is it possible that light wooden ships, unarmored gunboats, could sustain such a hail of shot and shell without being reduced, burnt up or sunk? It did not require nearly as great a number of projectiles, and they only of 14 c., to destroy before the Foo-Chow arsenal not one or two ships, but the whole Chinese fleet. On the other hand, what would have become of our wooden vessels if, instead of attacking the badly defended works of Mingan and Kimpai in reverse, they had been compelled to engage in front and had found them manned with skilfull and brave artillerists? Even if they had been deprived of the assistance of the 19 and 24 c. guns of the Duguay-Trouin and of the Triomphante?

Hence heavy guns at short range—this fact is confirmed by all the Min River operations—are as necessary to reduce good fortifications seriously defended, as to destroy an arsenal; and these heavy guns cannot act with security under the required conditions, unless the vessels carrying them, of a relatively light draught, are, above all, protected by suitable armor against the enemy's fire.

VI.

We have seen that, on the 23d of August, the destruction of the Chinese fleet was not accomplished without an effort on the part of the land batteries in the neighborhood of the Foo-Chow arsenal and of Pagoda Point to oppose it. From this time also our adversary's infantry shows itself disposed to do what is incumbent upon it in the struggle. At different times our little vessels are worried by its fire, particularly the gunboat Vipère, which approached the arsenal to destroy the floating stock. Welcomed at first by a shower of balls, very badly aimed, and fired by Chinese hidden in rifle-pits, she is next fired upon at 300 metres by soldiers that advanced bravely to the edge of the quays. To the volleys of our musketry the enemy replied by firing at the word of command,

leaving numerous traces of bullets upon the Vipère's hull. Happily, the captains of our vessels have taken care to protect their crews against such attacks by shelters of various kinds: bullet screens, armor of light chains, etc. These simple precautions will save more than one man's life.

As our squadron, successively taking the Chinese batteries in reverse, chased the defenders from one or another series of works, it became necessary to render the abandoned cannon useless, so as to prevent the enemy from remounting them when our ships would pass from before them, still bent upon the work of destruction upon which we counted to make the Pekin cabinet accept our conditions. Upon the sailors of the torpedo squad, protected by the landing parties and covered by the fire of our ships, fell the duty of accomplishing this. Here is shown the true role of gunboats in such expeditions; not to engage in battle—sterile as well at long range as at close quarters, and very dangerous for them in the latter case—against solid, permanent fortifications covered with guns, but to aid by every means in their power the doings of the forces operating on shore. Thanks to their light draught, they will be able to approach close to shore, to pass over or to stop upon shoals to which access is interdicted to heavier ships. They will protect all the movements of our armed boats, will cover as well the offensive march as the retreat of our disembarked sailors. With their 10 c. (3.94 in.) and 14 c. shell they will beat up all the lurking places, will worry the Chinese in their camps and behind their entrenchments; when the latter show themselves they will disperse them, or at least hold them at a respectful distance by means of musketry and Hotchkiss fire.

This also was the principal sort of service that, on a much larger scale, the gunboats often rendered the Federal armies during the war of Secession. One saw them on every river and in the shallow waters of certain Atlantic bays, covering the debarkation, the passage, the advance or the retreat of the land forces. At the big battles of Pittsburg Landing, Williamsburg and Malvern Hill, they either averted a Federal disaster or powerfully contributed to their final success by raining shell upon the enemy's columns.

Let us return to the operations of our squadron in the Min River. We now have to describe the destruction of the guns the Chinese have abandoned in the works successfully silenced by the guns of our cruisers, above all by the heavy guns of the Duguay-Trouin and of the Triomphante. Compelled to retain on board, particularly on the

gunboats, a large part of the crew, in order to be prepared for any emergency, the Admiral, as we have said already, only had available for this service a few hundred sailors. Full of good will and dash, the greater part of these brave fellows had never been employed in an expedition, and therefore could not possess, for this kind of work, either the experience or the solidity of old soldiers. To this cause of relative inferiority is added another of an entirely physiological order, independent as well of men's moral qualities as of their military instruction.

Should you remain, for example, a year aboard ship, then go ashore—on an unknown shore—in a broken country, from the very beginning you will feel as though dazed, your feet hardly will seem to be on solid ground, you almost will hesitate at obstacles formerly easily cleared, but of which, so to speak, you have no longer an idea—the smallest ditch, a slope, a thicket, etc.; your eyes will be astonished to see certain things formerly entirely familiar; finally—the most important detail in a case like the one now before us—*you will judge distances in a most completely inexact manner, no matter how well versed you may have been in this exercise before you went on shipboard.* These physical sensations which have just been summarily described have been experienced without doubt by every seafaring man, whether officer or sailor, after a long cruise. We are convinced they have had their influence on certain checks experienced under various circumstances, by disembarked sailors.

With his great prudence, his correct and firm judgment, Admiral Courbet took good care not to expose his feeble companies to such a misadventure, by throwing them forward through an unexplored country, away from the view or out of the range of his ships, against an enemy ten times superior in number and well entrenched. He is satisfied to send them ashore singly or by twos, under the protection of the fire of our ships and of our armed boats, to sustain the little squads of torpedo workers who were to burst the Chinese guns with gun-cotton. At each place, as soon as this duty is performed, our detachments return aboard as quickly as possible.

In this way, from the 25th of August, the landing parties carry off and bring aboard three small calibre Krupps, the torpedo corps destroyed the large 21 c. Armstrong which not long since enfiladed the Mingan Pass, all without serious opposition from the Chinese. On the 26th and the morning of the 27th are destroyed all the guns in the batteries of the Mingan Pass, with the same success and the same impunity.

A more energetic resistance met our ships, armed boats, and our landing parties above the Kimpai Pass. It was evidently in this channel, about 400 metres broad, still further narrowed by dangerous shoals, that the enemy expected to stop the exit of our squadron. Without taking into account the other artificial obstacles here accumulated, the Chinese had gathered numerous infantry.

"They wish, above all, to fight us with volleys. And really the natural configuration of the locality and the works they have executed here, greatly favored them in this funnel-shaped place. Upon the right bank crenated earthen walls and houses half way up gave them shelter; on the left bank brushwood, then a heavy dam, and finally the village of Fort White."*

It was necessary, above all, to destroy a large number of junks loaded with stones, ranged along the right bank, intended by the Chinese to block the pass. The evening of the 29th our gunboats support the boats detailed for this operation, which accomplished it capitally, though not without loss. Covered by a ridge on the left bank, some Chinese skirmishers annoy the gunboats Vipère and Aspic. In spite of the distance, about 1200 metres (1300 yds.), their bullets often struck. Two volleys of musketry from our little vessels and the accurate fire of the Hotchkiss compel them to retreat. From the right bank, however, come more dangerous attacks. Completely hidden behind the crenated wall that followed the ridge of a hill running from the river to the top of the heights, the Chinese skirmishers open fire upon our small boats and gunboats. The latter are obliged to shift anchorage and to approach nearer to the left bank so as to obtain diagonal fire upon the crenated wall.† Fortunately, our boats accomplish their object and in their turn retire.

The 28th, the operations against the defences of the Kimpai Pass are continued. The 14 c. guns and the cruisers' Hotchkiss once more dislodged the Chinese skirmishers from their shelter on both sides of the river; our shell explode a magazine and set the village of Fort White on fire. On the left bank, detachments thrown ashore destroy some guns, but run great danger; the points of landing are

*Admiral Courbet's report.

† It was while the Vipère was getting under way that a bullet mortally wounded Lieutenant Bruët-Villaumez, who on the poop of this little vessel was directing at the time the fire of the Hotchkiss guns. This valiant officer fell, a smile on his lips. Feeling himself fainting, "Carry me away," said he simply to the sailors stationed near him. He died without having recovered consciousness.

covered with electric torpedoes, and the enemy's skirmishers occupy excellent positions from which the fire of the ships cannot dislodge them altogether. Our men return aboard without succeeding in completing their work of destruction.

The same difficulties, only greater, on the right bank. Our landing parties are compelled to fight retreating before forces numerically overwhelming, and suffer sensible loss. Commandant Sango, chief of the expedition, is wounded. Two officers and eight men are unable to get off, but find cover behind a grounded steamer near by. Now it is that the utility of gunboats, of light draught vessels, makes itself felt in all its force. The Admiral sends the Aspic and the Lynx to anchor towards the eastward, a short distance from shore, so as to enfilade the valley leading to the fort, from which the Chinese descended; " under this protection, an armed boat rescued without a blow and brought aboard those left behind."*

It is easy now to take note of the important and decisive role, filled during this series of small descents, not only by the 14 c. and 10 c. guns, but also by the Hotchkiss and by the muskets of both gunboats and cruisers. No doubt the useful employment has been remarked, under different circumstances, and even aboard our ships, of musketry volley-firing. " This kind of firing cannot be too highly recommended, because you retain your men under some sort of control. Thus, they are compelled really to sight. They uncover to fire, but they fire coolly and with confidence. After the third or fourth volley the most timid act like the bravest." †

VII.

It remains for us to specify the services of the very first order rendered during all the operations on the Min River by the armed boats, and particularly by the steam launches of our squadron. Already we have seen the latter ready at need to protect the gunboats and the cruisers against the attacks of the Chinese torpedo boats. It is useless to insist again upon the importance of this. As we have already stated, a short time afterwards, some of these same steam launches carried the Chinese cruiser Foo-Poo by boarding, after she had been struck by the torpedo boat No. 45. An unforeseen episode of the struggle, without doubt due to the inspiration of the brilliant officer commanding our boats, taking place, however,

*Admiral Courbet's report. †Report of the captain of the Vipère.

under circumstances exceptionally favorable to success, such a fact should not be allowed to produce any illusion.

Formerly when in a calm, the sails, the only motive power of the vessel, hung inert along the masts, many times boats filled with armed men, in broad daylight and upon open water, have been enabled to obtain possession of a ship, even of some force and well defended. Steam, for some years past, has rendered such bold strokes almost impossible, even for boats themselves also possessed of this means of locomotion. February 19th, 1868, at the time of the passage of a Brazilian squadron under the batteries of Humaita, some Paraguayan soldiers in about twenty ordinary flat-boats attempted to board the little monitor Alagoas, which, some distance behind the other vessels, was with difficulty ascending the river. This effort failed. Three of the Paraguayan boats were sunk by the ram of the Alagoas, three others by her grape.

The carrying by surprise, during night or fog, of a vessel at anchor, is the only operation of this sort since the application of steam to navigation, that seems to present possible chances of success. It was thus during the night of March 1st–2d, 1868, near Humaita, that some thirty Paraguayan row-boats, secured two and two and each carrying 25 men, boarded the Brazilian coast defence ironclad Lima-Barros. This time again the assailants were repulsed. During the War of Secession, Confederate boats, more successful, carried two Federal gunboats by boarding, the Underwriter and the Water-witch, at anchor, the one in the River Neuse, the other in Assabaw sound.

But to-day, with revolving cannon and the photo-electric apparatus of which ships make use for their defence, can such efforts have the same chances of success? Evidently not. It generally will be found much surer to attempt the destruction of a hostile ship by means of torpedo boats than to confide the almost impossible task of her capture to armed boats.

Hence, the carrying by boarding of the Foo-Poo by some of our boats should be regarded as an exceptional, almost an abnormal incident. But this feat of arms does not limit the doings of our steam launches during the 23d of August. After having rendered unfit for service several Chinese torpedo launches, they destroy in the custom-house arroyo junks and sampans, without doubt destined for fire-ships. Next day they display the same activity. While some finish clearing the custom-house arroyo, the others, under the protection of the Volta and the gunboats, destroy the fire-ships and the floating material collected above the arsenal.

After the morning of the 25th a not less important, and perhaps more delicate task is imposed upon our armed boats: that of landing, of seconding and of covering the squads charged, at many different and numerous points, with the task of rendering the Chinese guns unserviceable. These operations, often interfered with by the strong current, continued until the 28th and gave rise to several lively skirmishes.

While the greater part of our squadron was fighting at Pagoda Point and in the Mingan Pass, the Chateau-Renault and the Saone were detailed to prevent the obstruction of the Kimpai Pass by the Chinese. Their boats accomplished the most arduous portion of this duty by the incessant vigilance they exercised during the night. When the Admiral anchored above Kimpai the 27th of August, it was these same boats that destroyed, under the protection of our gunboats, the junks loaded with stones by the enemy with the intention of sinking them in the Pass.

Finally, as a last obstacle, the evening of the 28th, our squadron find the narrowest part of the channel barred by a line of rafts. The pilots declare these rafts sustain electric torpedoes. During the course of the following night our boats drag the Pass carefully, visit the rafts and satisfy themselves that the information given by the pilots was erroneous.

Such is the long list of the multiplied services rendered by the armed boats during the continuance of the operations in the Min River. Here certainly is matter for reflection. If a division of torpedo boats is to-day one of the indispensable elements of any naval force operating upon a hostile coast, should not one say the same respecting steam launches that tow, transport, shoot, penetrate everywhere and destroy the material that the vessels' shells cannot reach? Referring to the debarkation of one of the detachments detailed to break up the Chinese cannon, Admiral Courbet notices in his report that "the current rendered the transportation of these people very difficult." In many cases, the speed of our steam launches as well as their power of traction seemed to be altogether insufficient. For operations like those in the Min River, boats as speedy as torpedo boats, but very different from them, are needed, very much shorter, easily shipped, easily managed, of light draught, capable of running anywhere, and of receiving a good armament. That is to say that the type of "fighting steam launch," capable of aiding the "counter torpedo boat," or of taking its place to a certain extent during the absence of the latter, is yet to be devised.

VIII.

When one reads attentively Admiral Courbet's report on the Min River fights, one thing more perhaps than anything else strikes one—the enormity of the task accomplished from the 22d to the 29th of August by the 1800 sailors of our squadron, and the amount of perilous hard work endured by this handful of men in such a short space of time. They were, indeed, at the extremity of an impassable road, before a hostile arsenal, surrounded by men-of-war, fire-ships, torpedo launches, batteries and armed men; having behind them a narrow channel 12 miles long, lined with other batteries, commanded by heights where were encamped soldiers ten times their superior in point of numbers, and terminating in a much narrower funnel-shaped mouth, for the closing of which their adversaries had prepared everything. Well! After six days not only had our little squadron come forth safe and sound from this impassable barrier, but it had destroyed nearly everything; arsenal, men-of-war, fire-ships, torpedo launches, barriers, cannon of the batteries. The struggle carried on by it comprehended all kinds of operations likely to be undertaken by a number of men-of-war: naval action, with cannon, torpedoes and with muskets; boarding a vessel from boats; defence against fire-ships and torpedo launches; bombardment of an arsenal; fights against batteries and against infantry; debarkations; shore fights; destruction of barriers, and dragging of a Pass—nothing is wanting.

Another thing, and this entirely to the honor of the chief of our squadron, is shown equally from reading his report. If there be a principle daily applicable to the operations of a war navy, it is that which consists in claiming from each type of ship, from each kind of arm, from each category of men, everything, absolutely everything possible, but nothing more. Thus it is easy to see that during the Min River fights this principle never was departed from. Truly, it would have been very difficult to have required from our sailors, from our vessels and our boats, from their cannon, from their torpedoes and their muskets, more energetic or prompter services. On the other hand, measuring with a clear view the advantages to obtain and their cost, the Admiral guarded against every foolhardy enterprise, against all dangerous stubbornness. When he has found that our 28 kilogramme shells can not ruin the arsenal, he draws off, reserving his ammunition for a more essential work; when he judges that his landing parties will not succeed in destroying certain

cannon on the left bank of the river, without considerable loss, he does not hesitate to recall them. It is thus that a chief acquires the right to expect everything possible from his subordinates; it is thus that are produced, almost naturally, results that one could hardly count upon.

If one will place one's self at this point of view, the Min River fights will be highly interesting. Have we reached the point where we can show that one also can gather precepts of another sort? We leave it to the reader to answer. But we wish, above all, that he will not be able to give a false or exaggerated interpretation to our reflections, and for this we undertake to close our labor with a few lines which will perhaps throw a little light upon the subject.

We are a firm believer in the power of the offensive torpedo as a weapon of fighting boats. To this several of our studies previously published in the *Revue Maritime et Coloniale* will bear testimony. The Whitehead torpedo seems to us to be excellent for swift boats under certain circumstances, but not under all. Hence we are doubly joyful over the brilliant success of Nos. 45 and 46 at the Foo-Chow fight. May this success bring back attention, and some favor, to the modest spar torpedo, already old, with which nobody any more concerns himself; truly only too much despised in spite of the services it has rendered!

We are a believer in the power of the torpedo boat, not less than in that of her torpedo. But this power has limits drawn by the dimensions, the provisioning, the nautical qualities, the *habitability* and the vulnerability—in a word, by the very nature of the boat. To imagine that because two torpedo boats of 50 tons—rather large, we wish it understood—made, with or without the squadron of evolutions, several fortunate passages in the Mediterranean, to imagine that boats like these will be able to vanquish and to replace large men-of-war upon the ocean is an illusion of the most dangerous kind.

Still another illusion, and also a very dangerous one, is to believe that the electric light and revolving cannons when available to her adversary, are means of defence that a torpedo boat can despise. Equally upon this subject we have had the satisfaction to find amidst the muliplicity of operations performed in the Min River a fact coming to the support of our ideas. Far be it from us, though, to seek there for an argument against the introduction, each day more extensive, also each day more logical, of torpedo boats amongst the

elements of coast defence or coast attack. We simply wish to place before all this opinion against too absolute formulæ, like the following: "A squadron attacked at night by torpedo boats is a squadron lost."* No, indeed, it will not be lost, no matter what may be the number of its adversaries, if it is properly armed and lighted, protected at its anchorage by exterior defences appropriate to the circumstances, guarded by swift counter-torpedo boats and other steam launches, if its personnel is brave, exercised and kept strictly vigilant.

We think that unarmored vessels, carrying medium calibre guns, and whose light draught has been sacrificed to speed or the reverse, following the duties they have to perform—we think such vessels will be indispensable to a large navy. But we are certain—and the Min River fights, after many others, confirm our opinion—that large calibres are necessary, particularly for coast wars.

Finally, we think that if it were possible from this time forth to remove the armor belt from the line of flotation, by means of the protection given to the underwater body of a fighting ship by a well-conceived cellular or alveolate system, the cuirass will still remain the only efficacious defence of the upper works against the terrible effects of modern artillery.

Above all, one must be upon one's guard against rejecting as useless this costly floating material which, in spite of all that may be said, has proved its worth under many circumstances during the American war of Secession, in Paraguay, at Lissa, and upon the coasts of Chili and Peru. The torpedo, no more than formerly the ram, has not yet "virtually killed armor";† while a fighting ship possesses a solid hull and a good engine she can render useful service. The wooden ships of Farragut in America, of Tegethoff at Lissa, of Courbet in the Min, triumphed brilliantly over obstacles which they hardly seemed fit to surmount. Our old ironclads, led by chiefs of this kind of valor, would know even yet how to make light of cannon, or of ram, in a way to disconcert an enemy that should have committed the imprudence of despising them.

*Automatic torpedo boats and the future of the Navy. By M. Gabriel Charmes, p. 130. †*Id.* p. 163.

NAVAL INSTITUTE, ANNAPOLIS, MD.

ON THE COMBUSTION OF GUNPOWDER IN GUNS.

By Lieut. J. F. Meigs, U. S. N.

The object of this paper is to present what seems to be a reasonable explanation of what are commonly called "wave pressures" in guns. When charges of powder are fired under certain conditions of loading, the readings of pressure gauges placed in different parts of the chamber differ very sensibly; and the pressure to be anticipated, instead of being capable of being predicted with reasonably accuracy, seems capricious and unfettered by law. It appears that the cause of these effects, though they are in different cases apparently due to very different causes, may all be ascribed to the powder being placed in bad geometrical conditions as to its lighting and burning.

It is necessary to note in the first place that the pressure depends very intimately upon what the French call the density of loading, which is the weight in unit volume of the powder in the charge form. If the weight of powder in a fixed volume be large, obviously the pressure will be high, and *vice versa*. Before a charge is lighted, the density of loading is the same throughout its volume; but if by any cause, as by an irregular formation of gas at different points of the charge, it be deformed and pressed violently, the density of loading at the instant of burning of any part may become variable, and may be very high at some points.

If we conceive a very large sphere of grains of gunpowder—the sphere being so large that the dimensions of the grains may be neglected when compared with its own—to be lighted at its centre, it is evident that the parts just lighting will at any instant lie on a spherical surface whose centre is the point of ignition. If we pass in along a radius of this surface, we shall pass through regions in which the pressure is higher and higher, and in which the heated gas is moving outwards through the interstices of the portions of the

grains which are still unburned at high velocities. If now we conceive a cylinder of some unyielding substance to be passed through the sphere of grains of powder, with its axis passing through the centre of the sphere, it is evident that we shall alter the circumstances of burning. The lighting surface will still be a sphere until it touches the cylinder; but at that instant, since the directions in which the gas already formed may escape become limited, the velocities of flow in the available directions must increase. Further, as the radius of the unyielding cylinder contracts, the conditions favoring the equalization of pressure become worse, until, by the contraction of the cylinder's radius, the powder to be burned becomes a long thin cylinder. When, further, we conceive an unyielding diaphragm to pass through the cylinder at the point of ignition, we have nearly the conditions of burning of a long thin charge.

In a very lucid and admirable paper on the "Heavy Guns of 1884," read at the Royal United Service Institution on June 20, 1884, Colonel Maitland states the following:

"The principle of chambering, that is, of enlarging that part of the bore which contains the explosive, depends upon a peculiarity in the action of powder charges which is not very generally known or understood. I will endeavor to make the facts clear to you. Supposing I fill a chamber which measures 1.15 in. in diameter and 18.6 in. in length with R.L.G.[2] powder, at a density* of 35.6 cubic inches per lb., as in the proof charge of the 12-pounder muzzle-loading field gun; the pressure will be extremely capricious, varying from about 26 tons to 37½ tons per square inch; the velocities will vary also, but to nothing like the same extent. Next, supposing I fill a chamber which measures 7 in. in diameter and 18.6 in. in length with 20 lbs. 3 ozs. of R.L.G.[2], at the same density as before, as in the 7 in. muzzle-loading gun; I shall get fairly regular pressures and velocities; the pressures will be about 22 tons only, varying about a ton above and below, although the densities of the charges are equal, and there is more than five times as much powder in the charge which gives the lower pressure. This anomalous result arises from the shape of the chamber. It is found that long narrow chambers favor the development of 'wave pressures,' as they are called, in a surprising degree, and experience has clearly shown that to get the best effect out of the charge, the

* For definitions of the term *density of charge*, as well as density of loading, see Text Book of Ordnance and Gunnery, published at the Naval Academy, 1884.

chamber should not be longer than from three to four times its diameter; with a powder which is slow in proportion to the size of the gun, it is generally safe to approach four diameters in length; but with a powder quick in proportion to the size of the gun, it is often dangerous to exceed three diameters in length. The cause appears to be that as soon as the charge is lighted the gas first evolved travels through the chamber from end to end with great rapidity, and sets up a dynamic action of a vibratory or wave character.

"But if it is asked why increasing the diameter of the chamber should mitigate and indeed remove this action, I have to confess frankly that I do not know. In the cases given the gas has just as far to travel, and to acquire momentum in, but it seems to lose the intensity of its rush from end to end when afforded increased space laterally. Many efforts have been made to overcome this difficulty, and to obtain satisfactory combustion in long narrow chambers by means of extensive air spacing, or by introducing central tubes of zinc and other substances; but the results have not been very promising, and in the Royal Gun Factory we have kept all our chambers short and thick, so as to consume the charges under the most favorable conditions."

The violent motion of the gas which is here described no doubt takes place; but it is the *effect* and not the *cause* of the differences of pressures as registered by the gauges.

The experiment which Colonel Maitland cites is very apt, and seems to present the solution which he seeks. In the two cylinders, if they were each lighted all over their cross section at either end, their conditions of lighting and burning would be absolutely identical. For we may conceive the larger cylinder to be made up of a number of the smaller ones; and the reasonable assumption that the dimensions of the grains are small when compared with those of their containing envelopes being again made, it is apparent that each of the smaller cylinders will light and burn along their length precisely as though they were held in an unyielding envelope.

If, however, each of the two cylinders were lighted at a point, as was undoubtedly the case (though this statement is not made), then the conditions for the approximate equalization of density of loading and of pressure in the small cylinder are evidently much less favorable than in the large one. The surface which is just lighting in the former will very soon be a right section of it; while in the latter this surface will be nearly a hemisphere, and will approach a right section of the cylinder only after the lapse of a longer time.

It is clear also that anything which favors the rapid formation of gas will tend to produce inequalities of density of loading at the instant of burning. So that although we may find in any chamber that the pressure is tractable under certain conditions, yet we can by no means infer that this will still be the case with a quicker powder.

A large value of the ratio $\frac{\text{length of chamber}}{\text{diameter of chamber}}$ appears then, in the conditions of lighting universally adopted, to be an unremovable cause of inequality and violence of pressure in the chambers of guns; and, as is well known, in order to keep this ratio within certain limits, the increasing of the diameters of powder chambers, with all its attendant evils, has been resorted to. If by any expedient in lighting the charge at many points and yet delaying its action somewhat so that the shot could get away before the whole charge is burned, this evil can be removed, a great improvement will be made.

It is interesting to examine what might be the probable effect of lighting the charge axially at its front end. In this case, since the shot moves more readily than the gun, it appears at first sight as though the conditions as to pressure might improve over the rear ignition, as parts of the gas formed would expand in the direction in which the shot is moving; but the parts of the charge which would burn when their density of loading was high would, in this case, be those near the breech plug, and it appears reasonable, therefore, to regard this method of ignition with distrust.

NAVAL INSTITUTE, WASHINGTON BRANCH,

JANUARY 3, 1885.

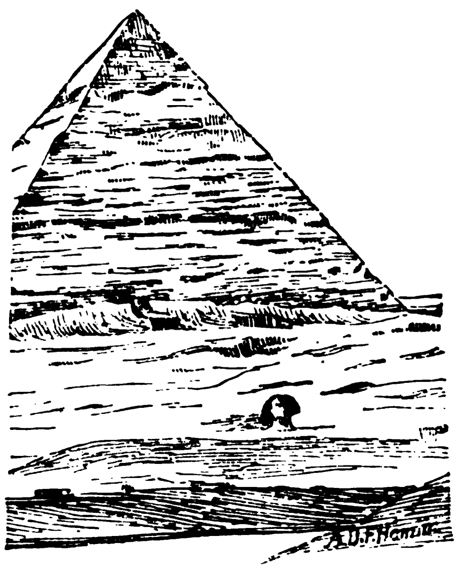
COMMANDER C. F. GOODRICH, U. S. N., IN THE CHAIR.

MŒRIS: THE GREAT RESERVOIR OF MIDDLE EGYPT.*

WITH THE TOPOGRAPHY AND CONSTRUCTION OF THE PYRAMIDS.

BY COPE WHITEHOUSE, M. A.

Top of Second Pyramid,	642.9
Top of Great Pyramid,	612.10
Top of Third Pyramid,	406.8
Top of Hill, . .	250.0
Base of Third Pyramid,	203.8
Base of Second Pyramid,	195.3
Base of Great Pyramid,	162.1
Head of Sphinx, . .	80.0
Excavated Chamber, .	60.0
Sand plain at Base, .	33.8
High Nile of 1838, .	24.8
Low Nile of 1838, . .	0.0



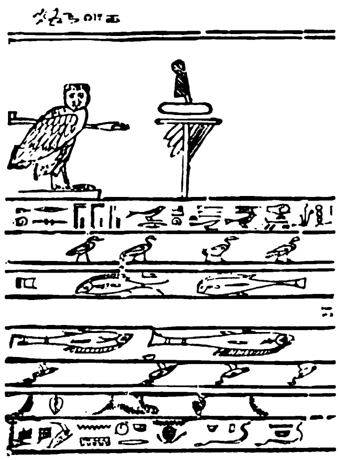
THE PYRAMID-HILL OF GIZEH FROM THE EAST.

The maps of Egypt prior to the publication of my researches in October, 1882, represent the desert to the southwest of Benisuef as an elevated plateau. The map of the French Expedition, following D'Anville, supported by the obser-

* A brief summary of the lecturer's remarks.

vations of MM. Jomard and Martin (Jan. 29th, 1799), indicate a *Grande Butte Pyramidale*, called the Heram Medaie el-Hebgad, 14 kilometres to the southwest of the Quasr Qeroun, a temple in the Desert at the southwest extremity of the Birket or Lake el-Qeroun. On the map of M. Linant de Bellefonds there are ridges suggested by shading of color, but in an extremely vague manner. At the meeting of the British Association at York (1881), I had shown that the ancient writers agreed in describing a vast impounding reservoir in Middle Egypt, to the southwest of Memphis, 450 miles in circumference and with a depth of 300 feet below high Nile. The account was so circumstantial in its description of a lake, blue in color, with twenty sorts of fish; its shores occupied by multitudes of fishermen engaged in catching and salting the fish, while the upper plateau was correspondingly fertile. The products of its fields were the best crops of Egypt. Its borders were lined with terraces of vines and olive trees, while broad stretches of pasturage enabled the government to support the flocks and herds of the State during high Nile without the expense of storing grass or the necessity of driving them to the Oases. The existence of this lake was denied. In 1840 M. Linant had suggested an alternative which had been universally adopted and supported by a large body of evidence. It had even obtained the endorsement of such a competent observer as M. Mariette, who with Dr. Brugsch interpreted a papyrus map as proof conclusive that the theory of M. Linant was correct. On this papyrus, however, it will be observed that there is no line of conventional leaves representing vegetation, on the upper or western side of the Lake. This was attributed to a mistake of the cartographer. Such an error was scarcely credible. If it was not an error, then it was a conclusive proof that Lake Mœris lay under the western hills of the desert, where the Birket still continues to receive the water of the Bahr Jousuf; and not on the upper plateau between the Birket and the hills which separate the Fayoum from the Valley of the Nile.

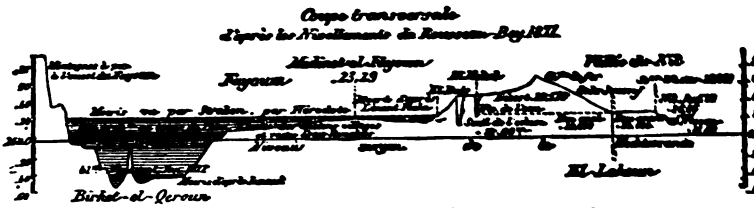
MAP OF EGYPT WITH LAKE MŒRIS RESTORED.



The section of the Fayoum as given by Dr. Lepsius is so plainly opposed to natural laws that it inspired no confidence. A bank of alluvial deposit could not have been formed as is represented, nor was it fair to measure the length of the reservoir which would be formed by converting a defile into a lake as equal to the length of the stream which meanders through it.

ERRONEOUS SECTION OF LINANT DE BELLEFONDS.

Dr. George Schweinfurth had already published a map which showed that this section was hopelessly bad, and that the depth of the western depression was precisely the 250–300 feet given by the ancient historians. Even the latest geographers and cartographers had neglected this map. It was unknown to me

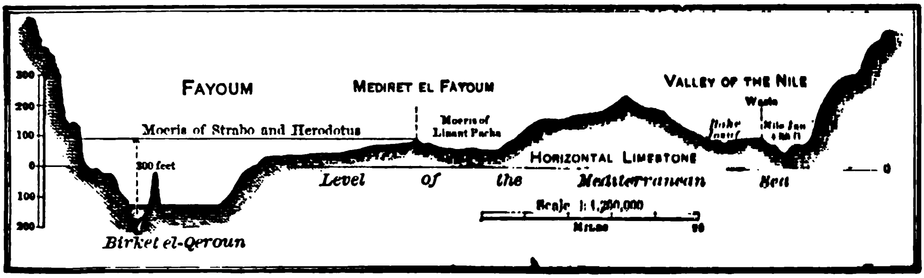


FROM THE REVUE ARCHEOLOGIQUE, JUIN, 1882. COPE WHITEHOUSE

until after I had reached the same conclusion independently. Schweinfurth's facts were verified by me also from the field-book of M. Kruger, lent to me by Rousseau Pasha (April 21st, 1882), from which I transcribe as follows:

De Medinet au Birket Quaroun (*sic*) + 23.290. Seuil de la porte d'entrée du Palais du vice-roi à Medinet + 23.000. Repère sur pont du Bahar Senhour +22.640;—17.463;—20.281;—22.949;—41.701. Eau amont à Ellahoun [Nile Valley] +24.694. Medinet audessus de la mer, + 23.290. Birket, — 39.705.

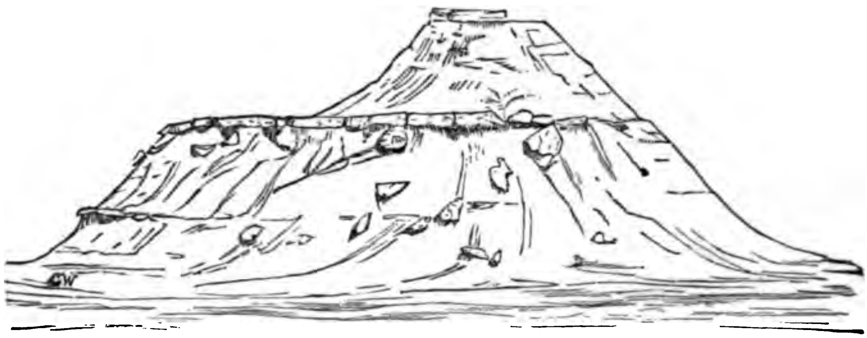
There is not the slightest doubt of the substantial accuracy of these figures, and an error of fifty feet would not affect the issue. A section through the Fayoum is, in effect, a complete justification of Herodotus and affords a most astounding example of human error.



SECTION THROUGH THE FAYOUM.

M. Jomard, although knowing that the depth had been fixed by all the ancient authors at between 250 and 300 feet, estimated it at between 20 and 24 feet (*six à sept mètres*), and M. Linant, correcting him, averred that the depth of 100 feet (32 mètres) was the result of a line of levels actually run by him when Director-General of Public Works.

It was necessary for me, however, to find a depression, equal in depth, to the south of the Fayoum. The existence of a *Grande Butte* confirmed me in the belief that there must be a corresponding erosion. The hills of the Libyan Desert are the remains of eroded strata, which assume a pyramidal form. The word Haram means pyramid. The Egyptians, however, never employ it in a general way, but confine it to these structures between the Mœris Basin and the Nile which are not all of them pyramidal.



PYRAMIDAL HILL IN THE DESERT. Long. 30° 55′.

An island with pyramidal summits once stood, according to the ancient historians, in the middle of Lake Mœris. Therefore, the Haram might, I assumed, prove to be the island. No other traveller had cared to venture into its inhospitable neighborhood. On the 3d of March, 1882, I satisfied myself that it was in a deep erosion. On the 3d, 4th, and 5th of April I ran a line of levels (for which I am indebted to my companion, Mr. Flinders Petrie), from the Fayoum to the eastern part of the same basin. Assuming Medinet to be +75 feet, the Wadi, or valley, sinks to —175, and the shore of the former lake is plainly marked beneath a commanding space of limestone, known as the Hagar Musqiqeh.

It seemed to me, from a careful collation of a large number of manuscript maps attached to the text of Claudius Ptolemy, that in the later period, after the drainage and irrigation canals of lower Egypt were in working order, and the cultivation of the land had been extended to the very edge of the Mediterranean and Mareotis, Bourlos and Menzaleh, with diminished area, had been converted into fresh water lakes, the great reservoir had been reduced to the Southern Basin, now known as Wadi Reian. I am well aware of the extreme importance as well as the apparent temerity in thus venturing to differ from all other students of ancient cartography. At all events it induced me on the 17th of March, 1883, with an Italian engineer of experience, detailed for this duty by the Cadastre, to run a line of levels fron the N. E. corner of Qasr Qerun to the surface of the lake. It is true that the canal which supplies this fortress and town was fed by a natural flow from the Nile, but it is equally certain that the limestone ridge which separates the Qerun from the Reian Basin is sufficient to confine the water in the southern part. Therefore the partial restoration of Lake Mœris is possible without any expropriation of cultivable land in the Fayoum. Whatever is done in the southern valley must

be wholly beneficial. The extent of the restoration would necessarily determine the mode of introducing the water. Drainage canals are as essential as irrigation canals. The waste water which is now turned into the Bahr Jousuf pours into the Birket Qeroun. But evaporation, since the opening of Ibrahimiyeh Canal, has not been sufficient to keep the lake at its former level. It would be a task of insignificant expense to reopen an old channel through drifted sand between the Charaq and Reian Basins. In that event cultivable land would be recovered on the shores of the northern lake, but the southern would only add extensive and valuable pasturages, or yield a single and precarious crop. No engineer would be content with this result, except as a step towards the completion of an impounding reservoir. But even this relief might aid the various enterprizes which have been proposed for the redemption of the lagoons of the coast. A more effective way would be by a channel direct from Behnesa across the desert, a distance of probably ten miles. The armorial bearings of this town—the Phœnix—have been preserved with the name for perhaps 3000 years. The appellation is peculiarly appropriate if a canal once led through the arid waste into the blue lake beyond. A hieroglyphic description definitely states that a canal of about 60 feet once conducted the water of the inundation towards the "Mœris of the West." In general, therefore, it is sufficient to show that the Egyptians, or more probably that invading race which seems to have anticipated the history of the Spaniards and Moors, had utilized this remarkable feature in the topography of Egypt, and that what they did could be repeated at infinitely less cost. The work to be done is that which has already been accomplished. Success is assured. The labors of these ancient engineers are still in some measure available here, as M. de Lesseps used the work of Nectis in the Fresh-Water canal.

The outcome of the scheme proposed is thus summarized in the *Century Magazine* for October last:

"The conclusion of Mr. Whitehouse's labor, then, seems to be that a basin exists of sufficient depth and other dimensions,—a basin worthless for all other purposes than those of storage,—situated near the Nile, and easily connected with it by a comparatively inexpensive canal, already once dug and still visible in parts, and utilized in long sections; that this must have formed the southern part of the ancient Lake Mœris of Herodotus and Strabo; that, if this part only were restored, it would hold in storage, to be made useful in irrigation, if necessary, all the waste waters of the overgrown and much dreaded Nile floods; that, if so used, the Berket-el-Qeroun, which since the opening of the Ibrahimich Canal has encroached on the tillable soil, could be reduced to one-half its present size, and thus many thousand acres of good land be restored to its borders," etc.

A scheme so easy in its execution, and so wide-reaching in its beneficial effects, is certainly deserving of the serious consideration of all interested in engineering works, in the general question of the improvement of the conditions of human life, or in its special development in that wonderful region—ever old and ever new—the Land of Egypt.

PROFESSIONAL NOTES.

TESTS OF ANTI-CORROSIVE ANTI-FOULING COMPOSITIONS FOR THE BOTTOMS OF STEEL SHIPS.

MADE BY THE NAVY DEPARTMENT UNDER THE DIRECTION OF THE NAVAL ADVISORY BOARD.

BY LIEUTENANT-COMMANDER F. M. BARBER, U. S. N.

The importance of protecting the bottoms of iron and steel ships from corrosion and fouling cannot be overestimated. Corrosion involves the life of the ship, and fouling involves the speed and consequent economy of maintenance. Generally speaking, two methods are resorted to for obtaining the desired result.

First.—Sheathing the bottom with wood, covered by copper or zinc. *Second.*—Covering the bottom with paint. The first method requires the stem and sternpost to be made of bronze, it necessitates the most skilful workmanship, it adds 10–12 per cent. to the weight of the hull and 15 per cent. to the cost, and if there are hidden imperfections in the workmanship corrosion is still possible. The second method is much simpler in theory, but in practice it has been found exceedingly difficult to obtain a paint with the requisite qualities.

It was with the above ideas in view that the Naval Advisory Board, in 1883, recommended to the Hon. Secretary of the Navy that a series of tests be undertaken in order to determine the best paint for the bottoms of the new cruisers. The recommendation being approved, manufacturers of paints were notified through the press, and circulars were sent descriptive of the objects of the undertaking and the method of procedure. Naval Constructor S. H. Pook, at the Washington Navy Yard, was placed in immediate charge of the experiments, and under the supervision of the Board the following programme was carried out: 496 plates, 3 ft. square and ⅛ in. thick, of the same quality as that used for the outside plating of the cruisers, were obtained. All but 16 of these plates were carefully cleaned by immersion in a bath of sulphuric acid and water, and then washed and dried. There were 28 different manufacturers competing, and 16 plates were painted with each kind of paint, 16 plates were also painted with a mixture of red lead and white zinc, 16 with pure red lead, and the 16 uncleaned plates were also painted with red lead.

The plates having been prepared, they were placed in cages, each cage containing 8 plates, 3 inches apart, carefully insulated from each other and from the cage by rubber. The cages were then distributed between Portsmouth, N. H., Washington, Norfolk and Key West, so that each kind of paint was represented on two plates at each locality. At the three northern places the cages were suspended from scows secured in favorable situations. At Key West it was found necessary to suspend them from an open wharf. In addition, the iron tug Speedwell was painted with each kind of paint, the bottom being blocked out so that the paint farthest forward on one side was the farthest aft on the other. At the water-line red lead and white zinc only were used.

The plates were immersed and the Speedwell launched in December and January, 1884. The first examinations were made in May and June, 1884, and the second in September and October, 1884.

At each examination a most minute and careful record was made of the following particulars: 1. Proportion of plates from which paint was peeled. 2. Proportion of paint loose or blistered, or from which anti-fouling was dissolved. 3. Average thickness of fouling. 4. Nature of fouling. 5. Evidences of corrosion or pitting, and in addition, on the bottom of the Speedwell, the time of drying of the fouling. During the interval of the tests the Speedwell had been from Washington to Portsmouth, N. H., but had remained most of the time at Norfolk.

As a result of the tests, the paint of Mr. P. G. West, of Wilmington, Del., was shown to be, under these circumstances, excellent. Its plates were only slightly foul, and on the Speedwell its space was almost absolutely clean and perfectly dry in a few minutes after the water had left it in the dock. In all cases it had adhered to the plates well and there was not the slightest evidence of corrosion. The paint of Mr. Gould, of Newark, N. J., was next in order, but considerably behind the West paint. The paints of Messrs. Devoe and Messrs. White & Co. were far behind the Gould. All the others were unsatisfactory.

Recognizing, however, that where so many conditions are involved, a change in any may produce variations in the results, and as many applications from manufacturers were received after the tests were commenced, the Board has recommended another series of tests to be made, believing that the results will be valuable in proportion to the number of tests. This second series has already commenced, with 52 different samples.

The report of the Naval Advisory Board was published in full by the Department.

A FALLACY IN COMPOSITE GREAT-CIRCLE SAILING.

BY COMMANDER C. D. SIGSBEE, U. S. N.

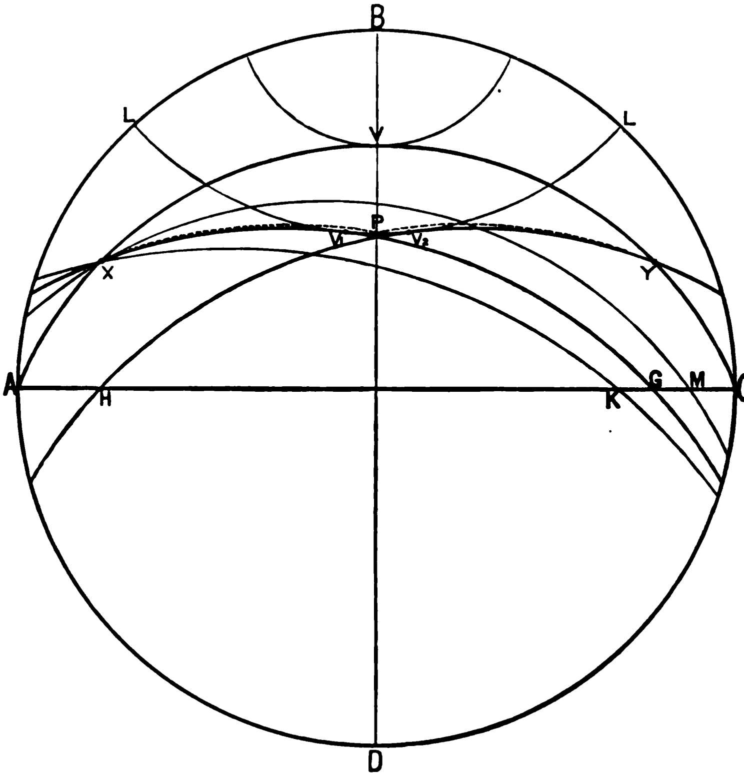
In the *American Journal of Mathematics*, for December, 1881, appears a paper, by Mr. Marcus Baker, which discusses an extension of Alhazen's problem to include cases of composite great-circle sailing. This paper, after reciting that the solution of Alhazen's problem gives the minimum path between two points and an intermediary circle, the points and circle being situated in the same plane, then proceeds to the solution of the same problem when the two points and the circumference of the given circle are situated in the surface of a sphere.

When the great-circle arc joining two places leads into higher latitudes than a navigator is willing to attempt, he decides on some lower latitude to which he intends to restrict his route, and he then composes his route in such a way as to obtain, under the restriction of limited latitude, a minimum distance between the places.

Unless the two given places are diametrically opposite points of the sphere, only one great circle can join them, and the commonly accepted shortest route, or composite route, between them in other cases, when the latitude is restricted, is made up of two arcs of great circles tangent to the limiting parallel of latitude through the two places and that arc of the parallel which is included between the points of tangency, or vertices, of these component great-circle arcs.

In the paper in question it is stated that the shortest path which does not pass beyond the limiting parallel of latitude, consists of two arcs of great circles drawn from the two places to a point upon the parallel in such a manner as to make equal angles with the parallel at that point. The object of the paper is to determine this point.

In determining his point, Mr. Baker fails to notice that his path passes beyond the limiting parallel, thus violating an essential condition of the problem in its relation to practical navigation.



The accompanying figure is a stereographic projection of the sphere upon the plane of a meridian. B and D are the poles, AC the equator, and AVC a great circle having its vertex at V. X and Y are two points upon this great circle, assumed in the same latitude for convenience of construction. LV_1V_2L is the limiting parallel. XV_1G is a great circle tangent to the parallel through X, and V_1 is its vertex or point of tangency. YV_2H is a great circle tangent to the parallel through Y, and V_2 is its vertex.

The ordinary composite great-circle route from X to Y is from X to V_1 upon the first great circle, from V_1 to V_2 upon the parallel and from V_2 to Y upon the second great circle. Mr. Baker's route is shown by the dotted line, P being the point which he determines, and which in the case projected falls upon the meridian of the vertex V, since X and Y are in the same latitude.

The limiting parallel will always lie on the polar side of the two places. From each place, then, arcs of two great circles can be drawn tangent to that parallel, one upon each side of the meridian of the place. Only those arcs need be considered which are tangent on the side nearest the other place.

Great-circle arcs through both places cannot have a common point of tangency upon any parallel of latitude excepting that of the vertex of the great circle which joins the two places, for such arcs must lie in the same plane and must therefore be arcs of the same great circle. Hence upon any lower parallel, tangent great-circle arcs through both places will have separate points of tangency as V_1 and V_2.

Great circles through either place, and passing, as XK, on the equatorial side of the corresponding tangent great circle, will not touch the limiting parallel. Those passing, as XM, on the polar side will intersect the parallel in two places and will therefore pass beyond it into higher latitudes. It is seen, then, that arcs of great circles through both places cannot be drawn to meet upon a limiting parallel unless one or both pass above that parallel.

FORCED DRAUGHT BY REVOLVING SCREW IN CHIMNEY.

By Passed Assistant Engineer John C. Kafer, U. S. N.

There have been some experiments made at the New York Navy Yard recently, with a revolving screw propeller in a chimney, which, when sufficient data have been obtained, will undoubtedly solve the question of forced combustion on shipboard.

These experiments were made by direction of Engineer-in-chief Charles H. Loring, U. S. Navy, Chief of the Bureau of Steam Engineering, Navy Department, who tried, in 1869, the effect of a screw propeller in a smoke pipe for the purpose of increasing the rate of combustion of coal. The results at that time showed that a great deal more coal could be burned per square foot of grate with a very large increase in the quantity of water evaporated per hour, than when burning coal by natural draught in the same boiler.

The trials made at New York with the boiler in the foundry of the Steam Engineering Department, showed that with natural draught and using the full grate surface of the boiler—twenty-four square feet—a ratio of heating to grate surface of 23.87 to 1, and a calorimeter through the tubes of about one-seventh the grate surface, the mean of 15 experiments of 16 hours each gave a consumption of 15.417 pounds of anthracite coal per hour per square foot of grate, with clean fires forced to maximum.

It is probable that not more than 13½ lbs. of anthracite coal per square foot of grate would be burned if the boiler was in the hold of a vessel, where the openings to the fire room are obstructed to the free passage of air, and where the passage from boiler to smoke pipe is not so direct as in the boiler used in the New York Navy Yard.

The chimney used is 70 feet in height above the grate, which is much more than the height of smoke pipes generally found on vessels of war.

With the screw in operation in the chimney, the mean of 10 experiments, averaging 16 hours each, gave a combustion of 17.917 lbs. of anthracite coal per square foot of grate, with 0.39 of one per cent. less water evaporated per pound of coal, but with an evaporation of about one-sixth more.

In the experiment with the screw, the boiler had the same grate surface, heating surface and calorimeter as in the previous experiments with natural draught, and it was apparent that the area through the tubes (one-seventh the grate surface) was much too small, as the pressure of the atmosphere in e fire room was at times equal to a column of five inches of water above the essure in the smoke pipe below the revolving screw.

A second series of experiments were made reducing the area of grate to 13½ square feet, keeping the same area through tubes and the same heating surface. This gave a ratio of heating surface to grate of 42.44 to 1 and a calorimeter through the tubes of about one-fourth the grate surface.

The maximum combustion with natural draught, under these conditions, as shown by a mean of four experiments of 16 hours each, was 19 pounds of anthracite coal per square foot of grate per hour.

With the screw in operation in the chimney and like proportions of boiler, the mean of five experiments of 16 hours each gave a combustion of 38.44 lbs. of anthracite coal per square foot of grate per hour, with an evaporation of 0.777 of a pound of water less, per pound of coal, than with natural draught.

With the screw and the changed proportions of boiler, the rate of combustion per square foot of grate was more than doubled, and the quantity of steam generated per unit of time was 80 per cent. more.

To take advantage of the benefits so clearly demonstrated by these preliminary experiments, it is necessary to make further trials to determine the relative proportions of heating surface, and area through tubes to grate surface for marine boilers; and when these proportions are established, the boilers of war vessels can be fitted with an appliance that will double their power in cases of emergency, without at all interfering with the ordinary conditions of burning coal with natural draught, and steaming at an economical cruising speed, as it was shown in these experiments that the presence of the screw in the chimney did not at all affect the rate of combustion with natural draught.

An eminent engineer who has seen the result of these trials and witnessed the operation of this principle, said that this is the only practicable solution of the forced draught problem.

The hatches and passage-ways can be kept open, and all conditions are the same as when burning coal with natural draught, and therefore will not have the same effect on the morale of the men as a closed fire room.

In comparing this system with that of a closed fire room where the pressure of air is maintained above the atmospheric pressure, it would seem at first sight to be less economical as far as power required to produce draught is concerned, as the gases generated by the combustion of coal, as well as the air supplied for combustion, must be moved by the screw in the chimney when they are highly heated and have a greatly increased volume, while with a closed fire room the air moved is of the temperature of the atmosphere.

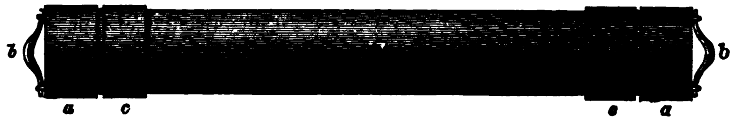
The volume of air moved in the case of the closed fire room may be much greater, however, than the volume of heated gases in the smoke pipe, on account of the unavoidable leakage, which in large fire and boiler rooms is very great; the coal bunkers must also be under pressure, as a free communication must be maintained between fire room and coal bunker; for these reasons it is believed that less power will be required to drive the screw in the chimney than to maintain sufficient pressure in the closed fire room to burn the same amount of coal per square foot of grate.

ORDNANCE NOTES.

No. 1.—Cartridge Cases.

The magazine arrangements of the new cruisers will differ radically from those to which we have been accustomed, the change arising from the enormous increase of powder consumption in modern guns.

Each cartridge will be carried, at all times, in its own "cartridge case"—a long cylinder of zinc, brass or other suitable material. The 6-inch cartridge will have covers *a*, *a*, at the ends, similar to those of an ordinary blacking box, except that these are fitted with handles *b*, *b*.

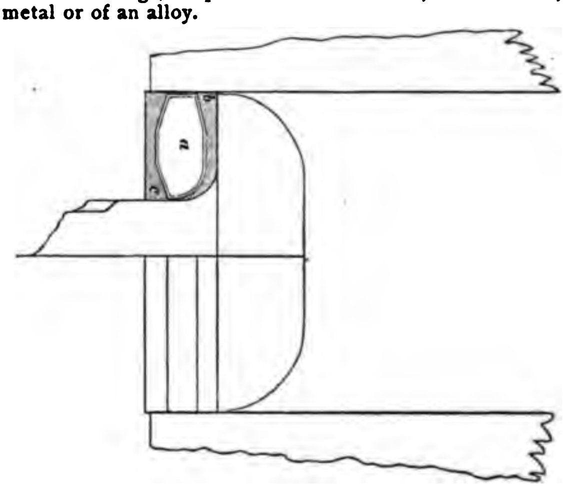


Collars *c*, *c* are soldered to the cylinder—a space being left between them and the covers when in place. In this interval stout twine is wrapped and the end is allowed to hang out. Over the twine is laid shellacked paper. The joint is sealed with shellac, and rendered watertight with asphalt varnish or other proper substance. The cases will serve the combined purpose of powder tanks, passing boxes and loading cylinders. They will be stowed in racks in the magazine, will be whipped up, when wanted, by the handles and taken to the gun. One cover being removed, the case will be inserted into the breech of the gun, the second cover removed and the cartridge pushed into the chamber from the rear by means of a short rammer.

For large calibre (8-inch and upwards) a mechanical joint may be used to connect the cover and cylinder. A number of simple and serviceable schemes are under consideration. The interrupted screw, the bayonet joint, a flat profiled thread, etc., etc., have already been tried or discussed; but the blacking box type is found to be strong enough and tight enough for all practical purposes. When it is remembered that a 6-inch cartridge is nearly three feet long, and fifty pounds in weight, the necessity for economical storage and facility of handling becomes apparent.

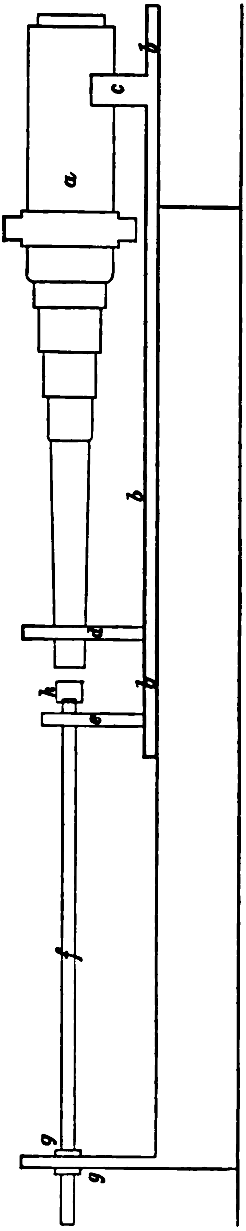
No. 2.—De Bange Gas Check Rings.

In the early application of the De Bange system of obturation to our new steel B. L. R.'s, the pad *a* filled with asbestos and mutton suet, was enclosed between two sets of rings, of peculiar cross section, made of tin, copper or other soft metal or of an alloy.



In practice, at the Naval Experimental Battery at Annapolis, these rings were found, after firing, to stick to the wall of the chamber, and thus to prevent the ready withdrawal of the breech plug. Experience showed the necessity of a harder material—a solution of the difficulty which, by the way, had been, from the first, under discussion theoretically. The premises admitted, the conclusion followed logically and speedily. In June last, the Bureau of

Ordnance ordered a pair of retaining rings, *b* and *c*, to be made of steel. Early in July, after ample trial, they were reported by the Inspector of Ordnance in charge of the Proving Ground (Lieut.-Commander Folger) to be entirely free from tendency to stick in their seats. They were at once adopted as standard.



CONVENTIONAL SKETCH OF 6" B. L. R. BEING RIFLED ON A PLANER.

No. 3.—Rifling Heavy Guns.

The operation of rifling is conducted in a variety of ways. Thus the gun may be fixed and the rifling tool *pushed into* it or pulled *through* it; or, the gun may be movable and the tool fixed longitudinally. In all cases some device is employed for turning the tool during its passage through the bore, so that the cut made may be a spiral of the required nature. Again, one groove or many may be taken at a time. Within these limits it is seen that there exists a wide field for diversity of practice; for instance, Woolwich cuts *one* groove at a time by *pulling*, while we cut *several* by *pushing*.

At the Ordnance Shops of the Washington Navy Yard, for want of a rifling machine of the usual type, the 5" and 6" B. L. R.'s have been rifled on a Sellers planing machine. The gun *a* is laid on the planer table *b*, supported on a chock *c*, and carried in a collar *d*, by which it may be revolved about its axis, and a new surface of the bore presented to the rifling tool whenever desired.

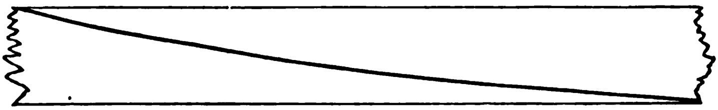
On the muzzle end of the table is a standard *e*, which passes freely along the rifling bar *f*, and serves as a support to it.

It has a stud projecting down into a spiral score in the bar. Necessarily, this stud causes the bar to rotate, making the groove in the gun an exact reproduction, in character, of the score in the bar. The rear end of the bar is held at the extremity of the planer bed against longitudinal strains by collars *g*, which leave it free to rotate.

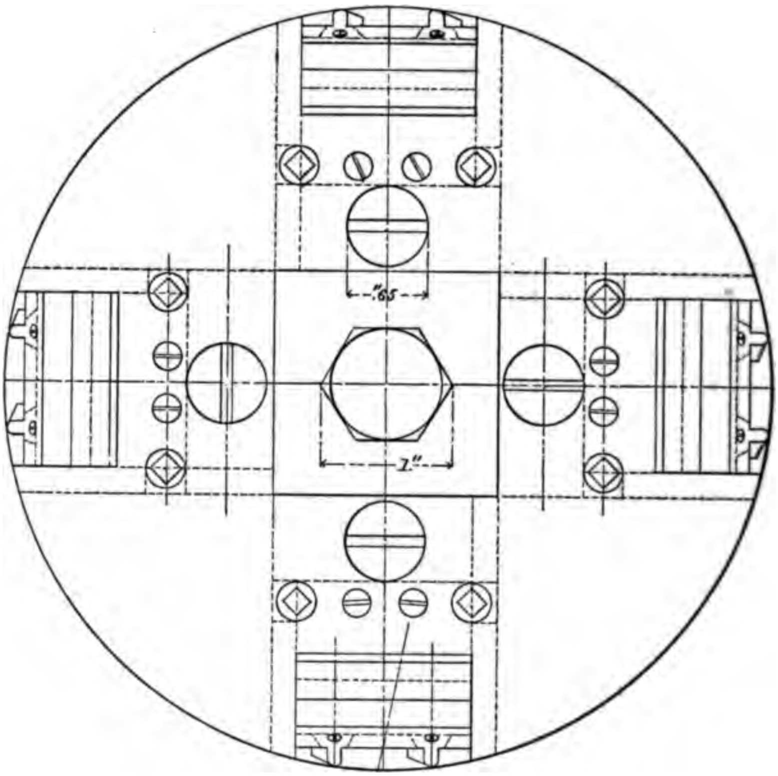
The other end of the rifling bar carries the "rifling head" *h*. The details of a 6" rifling head are given in the accompanying cuts. It will be observed that eight grooves are cut at once, and that each tool is independently adjustable by a screw as to depth of cut. Before beginning, set-screws, not shown in the drawing, are regulated to stop the tools at the *extreme* depth of the groove, and are not touched afterwards. In this way the operator is debarred from the possibility of making mistakes of adjustment, and thus ruining a gun by cutting too deeply.

The head here given was made last year by direction of the Inspector of Ordnance, and in view of the need of more rapid working than had been the practice before. It is merely an adapt-

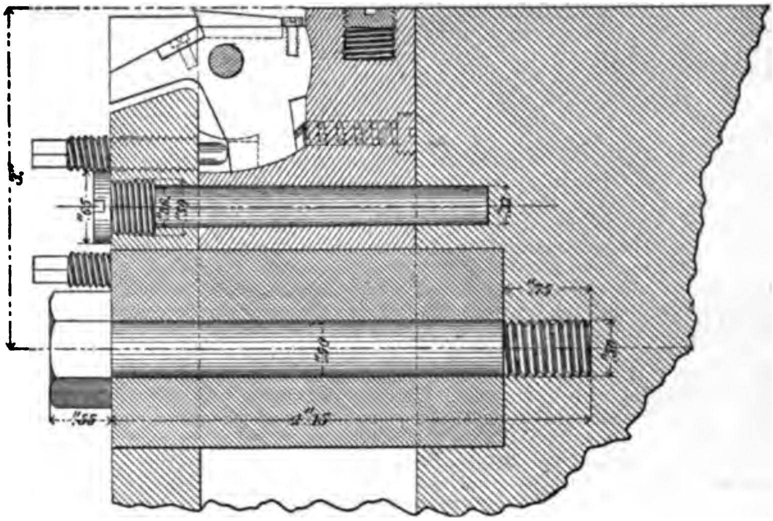
ation of the tool previously employed, modified so as to take eight independent cuts instead of one cut, single or double. It has already justified its greater cost in reducing the time of rifling a gun from about 12 days to 4 days. The twenty-four grooves of a 6-in B. L. R. are now "roughed out" in eight hours. Plans are also elaborated for a head to act by *pulling*, if found desirable, wherein



the condition of independent adjustment for each cutter is maintained. The scheme described is evidently capable of expansion so as to cut as many grooves as may be desired and found practicable.



ELEVATION OF 6-INCH POLYGROOVE RIFLING HEAD.



POLYGROOVE RIFLING HEAD—DETAILS OF TOOL-POST AND CUTTER.

USE OF OIL.

The Hydrographic Office has been collecting data to determine under what circumstances the use of oil is most efficacious in diminishing the danger of breaking seas during gales of wind.

Masters of vessels are requested to make experiments in this matter whenever the opportunity occurs, and report the results to one of the Branch Hydrographic Offices, or directly to the Central Office at Washington.

When sufficient data have been collected a pamphlet will be issued giving such directions in regard to the use of oil as the common experience of seamen may determine to be the best.

The following accounts have been received lately:

Capt. R. S. Thompson, S. S. Sacrobosco, reports using oil in 1880, and twice during the month of February, 1885. In each instance, after getting his ship before the wind, he put over oil bags with the best results. In the first case the engines were slowed so as not to lose too much to leeward, and it was proved clearly that with the use of oil it is not necessary to run as fast as is generally supposed.

Capt. Smith, of the English bark Emma, used refined petroleum during a gale in which his vessel was abandoned. He found it entirely useless, although barrels of it were emptied to windward, and seven or eight bags of it were towed alongside. About five gallons of crude turpentine or pine oil was used with good effect as long as it lasted.

Capt. Geddes, of the S. S. Erato, in February, 1885, instead of heaving-to during a favorable gale, concluded to run. He shipped some very heavy seas, which did great damage until the oil bags were put over, when the ship ran comfortably with the decks perfectly dry.

Capt. Daniel Thomas, of the British barkentine Corisande, in January, 1885, during a gale, while lying-to, was boarded by a heavy sea which washed one

man away and disabled the vessel, which lay in the trough of the sea. Men were stationed immediately to pour oil overboard until bags could be prepared and the vessel secured. When this was done she was easily got before the wind and ran very comfortably.

Capt. Johnson, of the English steamer Emerilda, reports using oil bags with excellent effect, during a heavy northwest gale, on his last voyage from Port Royal to Liverpool.

Capt. Moore, of the British bark Siddartha, says that during the last four years he has frequently used oil bags when hove-to or running, and has invariably found they made a wonderful change in the nature of the sea. His system is to fill a coarse bag with oakum, thoroughly saturated with oil, and to hang it over the weather bow, if hove-to, or to the bumkins, if running.

Chief Officer John Matson, of the English steamer Edinboro, in 1881, while lying-to in a mountainous sea in the Bay of Biscay, placed two oil bags overboard forward with the best results, the oil effectually preventing the sea from boarding the ship.

Capt. Scott, of the English S. S. Briscoe, during a recent passage from Baltimore to London, experienced heavy gales from WNW. to WSW., with high seas sweeping over the ship. He filled two canvas bags with oil and towed them over the stern with excellent effect, as they prevented the seas from boarding the vessel.

Capt. Mumford, of the British S. S. North Anglia, in October, 1884, during a hurricane, had his main wheel gear carried away, and was obliged to steer aft. After the men had been washed away several times he tried oil and had no further trouble. Again, in February, 1885, while hove-to, he poured oil through a pipe on each side of the forecastle. Oakum was put loosely into the pipes to prevent the oil running too quickly. After commencing the oil no dangerous water was shipped.

Mr. G. Foster Howell, of New York, sends a very interesting account of the use of oil while off the Horn in the ship Cavalier in 1876. The ship had been run too long, and heavy seas were constantly boarding her. At last one more powerful than the rest rushed upon her with awful violence and started the deck. At the writer's suggestion oil bags were towed overboard with about 25 feet of line, one on each quarter and one amidships. "No sooner had the oil commenced to leak than the sea ceased to boil and rage, and the waves became so harmless that they no longer broke upon us."

WAVE MOTIONS.

The ships of the U. S. Navy have been engaged for some time in making observations of the dimensions and speed of deep-sea waves. These recorded observations are not so complete or numerous as is desired, and any assistance in this respect will do much to advance one important branch of the science of naval architecture.

The observations made where a ship falls in with a single series of approximately regular waves are most valuable, and should be accompanied by full records of the attendant circumstances.

One method of measuring the wave lengths consists in towing a log line astern of a ship and noting the length of line when the chip floats on the wave crest next abaft that on which the stern of the ship momentarily floats. The ship should be head on, or allowance made for the departure of the log line from the head on position.

To measure the wave heights, when the ship is in the trough of the sea, and for an instant upright, the observer takes up a position such that the successive average wave ridges, as viewed by him from the trough, just reach the line of

the horizon without obscuring it. The height of the eye above the water level correctly measures the height of the waves. To measure very high waves the observer may have to ascend the rigging, while for waves of less height a station on one of the decks may suffice, or some temporary expedient devised for placing the observer near the water level. It is desirable to select a position as nearly amidships as possible, but if it becomes necessary to take a station near the bow or stern, allowance must be made in estimating the height of the eye above water for the deeper immersion which may be caused at the instant by pitching.

The longest recorded wave measured a half a mile from crest to crest, with a period of 23 seconds. Waves having a length of 500 or 600 feet, and periods of 10 to 11 seconds, are the ordinary storm waves of the North Atlantic.

In regard to the heights of waves, the most trustworthy measurements show from 44 to 48 feet to be a remarkable height. Waves having a greater height than 30 feet are not commonly encountered.

The Hydrographic Office has blank forms for recording these observations, and would be glad to furnish them to any shipmaster who takes sufficient interest in the subject to make observations whenever the opportunity occurs.

ON THE LAWS OF PENETRATION OF WROUGHT IRON PLATES.

The following is a translation of a mémoire by M. Martin de Brettes, published in the Comptes Rendus of the Paris Academy of Sciences, tome 99, No. 17, October 27, 1884.

An examination of Krupp's experiments upon the penetration of armor plates shows, calling $2r$ the diameter of the projectile, t the thickness of the plate, and e the energy of the shot per unit cross section, that:

1st. When $2r$ is constant, the quantity $\frac{e}{t}$ increases with t; so that the curve representing the relation between e and t may be considered a parabola.

2d. When t is constant, the quantity $\frac{e}{r}$ decreases when r increases, so that the curve between e and r may be considered a hyperbola.

3d. When $\frac{2r}{t}$ is constant, $\frac{e}{t}$ is also constant.

So that the law connecting the three variables r, t and e must be written so that the value of e shall be represented by a parabola, a hyperbola, or a straight line, according as $2r$, t, or $\frac{2r}{t}$ is constant.

The following form satisfies these conditions,

$$e = at + b\frac{t^2}{2r}. \qquad (1)$$

The following numerical data are given as proof of the three laws:

For the first, when $2r$ is constant, for the 15 cent. gun:

t	Δt	e	Δe	$\frac{\Delta e}{\Delta t}$
cent.		tonnes-métres		
15		1.500		
	5		.700	.140
20		2.200		
	5		.770	.154
25		2.970		
	5		.830	.166
30		3.800		

For the second, when t is constant, for $t = 20$ cent.

$2r$	$\Delta.2r$	e	Δe	$\frac{\Delta e}{\Delta.2r}$
cent.		tonnes-métres		
12		2.400		
	3		.200	.066
15		2.200		
	2		.080	.044
17		2.120		
	3		.050	.016
20		2.070		

For the third, when $\frac{2r}{t}$ is constant, for $\frac{2r}{t} = .75$.

$2r$	t	e	$\frac{e}{t}$	diff.
cent.	cent.	tonnes-métres		
12	18	2.060	.114	
				+ .002
20	30	3.470	.116	
				— .001
24	36	4.149	.115	
				.000
28	42	4.830	.115	

The above results determine the constants in (1), and give, in the units of the numerical data,

$$e = 0.073t + 0.027 \frac{t^2}{2r}. \tag{2}$$

This formula has been tested by repeated application to Krupp's results, and gives, when compared with experimental results, quantities which are sometimes too large and at others too small. It is thus thought to represent well the law connecting the three variables.

If we change (2) so that e shall be in foot-tons per square inch, and t and r in inches, it becomes

$$e = 3.863t + 1.429 \frac{t^2}{2r}. \tag{3}$$

The penetrating power of shot is sometimes considered to depend upon their energy in foot-tons per inch of circumference, and (3) may be easily transformed to suit this. If e_1 be the energy so stated, we have evidently,

$$\frac{e_1}{e} = \frac{r}{2},$$

whatever value t may have. Inserting this relation in (3), we have

$$e_1 = 1.932tr + 0.357t^2. \tag{4}$$

The particular curves represented by (4) when $2r$, t, and $\frac{2r}{t}$ are constant, will not, however, be the same as before.

The differences between the values given by (4) and by experiment are greater than in the case of (3), and they increase as the diameter of the projectile increases, since they have been multiplied by $\frac{r}{2}$.

REVIEWS.

Le Tir de l'Artillerie de Campagne. Par Major H. Rohne; traduit de l'allemand par le Capitaine Bodenhorst, de l'artillerie belge. Bruges: C. De Laroière, 1883.

The formation of rules by which to correct the fire of guns by the observation of the points of fall of a number of projectiles is now attracting much attention in Europe, and the rules which have been adopted by the Prussian land artillery are given in the above work. The subject is somewhat dry reading; it consisting here of nearly 400 pages, giving the minute detail of rules for governing the many kinds of fire which may occur.

It is to be regretted that the author does not give more fully the reason for the rules laid down. As is commonly the case with works of this kind, the reader is supposed to know all about the guns of whose use it treats. There is, however, much which is valuable and interesting in it, and from the great importance of the subject it cannot fail to be of interest to naval officers.

The rules given are applicable to the use, under the direction of one officer, of a considerable number of guns on a fixed platform, and these are by no means the ordinary conditions of practice at sea, where we seem likely to have comparatively few guns; but the principles governing the formation of rules are the same, and thus reading the work must develop an officer's usefulness in an important particular.

Traité de Balistique Rationnelle. Par J. Baills, Lieutenant de Vaisseau. Paris: Libraire Ch. Delagrave, 1883.

This work, as its title asserts, is a treatise on rational or abstract ballistics. It contains, as the author states in his preface, the treatment of some questions which are of theoretical curiosity rather than practical use. For example, the deviation of projectiles due to the rotation of the earth is treated at length; as is also the difficult subject of the rotation of projectiles in flight. The latter may, it is true, become of practical use by leading to the best methods of manufacturing projectiles and centering them in the bores of guns. The author has divided his subject into five books, having the following headings: Exterior Ballistics, Interior Ballistics, Deviations of Projectiles, Pointing and Firing Guns, Theory of Recoil. There is nothing calling for remark in the first book; the numerical solution of the trajectory in air is of course not attempted. The second book is divided into two principal parts: Geometrical and Thermodynamic study of guns. The former is of importance as presenting certain simple notions which lead to a clear conception of the phenomena which occur in the bore of a gun when the charge is fired; while the latter is a digest of the work of Sarrau, Saint-Robert, Noble and Able, and Clavarino. It may be worth noticing that the work of the last named author called Puissance de la Poudre, published in the Journal de l'Artillerie Italienne, which appears little known in this country, is frequently quoted as the most complete treatise yet published regarding this matter. The subject of deviations, as treated in the third book, has little or no application in practice. The subject of pointing and firing guns is well and clearly treated, and many facts and principles, a knowledge of which is essential in the use of guns, are to be found

here collected together. The last book, concerning the recoil of guns, contains the theory of that subject as applied to frictional and hydraulic checks.

The subject-matter of the book is presented generally in a mathematical form, as must be the case in a work of its intent. The methods used (with the notable exceptions of the deviations of projectiles, the thermodynamic study of guns, and the application of the theory of probability to the fire of guns, for example) are simple, and are accessible to a person who has a knowledge of the principles of mechanics.

A Treatise on the Application of Wire to the Construction of Ordnance. By James A. Longridge, C. E. E. & F. N. Spon, London and New York, 1884.

The use of wire in the construction of guns seems growing in favor, and the importance of a work on the subject by so eminent an engineer as Mr. Longridge cannot be overestimated. The first sensation of the reader who picks this book up must, however, be one of disappointment. The author states that it contains the results of investigations which began as long ago as 1855; and, if one may judge by its disjointedness and the great confusion in the mathematical notation, it must have been growing in an irregular way during all that time.

The fundamental formulae used by Mr. Longridge are those usually known as Lamè's or Rankine's. The most satisfactory and simplest method of deriving these two laws concerning the elastic strength of thick hollow cylinders which has yet appeared is due to Professor Cotterill, and will be found in his Applied Mechanics (London, Macmillan & Co., 1884); Mr. Longridge's method cannot compare with it in simplicity and elegance. Throughout the work the question of the *compound* strength of guns, in which subject Clavarino is at present the received authority, is not touched upon.

Notwithstanding the extremely bad mathematical methods which Mr. Longridge has used and the other faults which have been pointed out, no one who wishes to make himself a specialist in this subject can fail to read this book. As for the student who is beginning the subject, he had better begin elsewhere.

Applied Mechanics: an Elementary General Introduction to the Theory of Structures and Machines. By James H. Cotterill, F. R. S. London: Macmillan & Co., 1884.

The author's position as professor of applied mechanics at the Royal Naval College, Greenwich, led to the preparation of the above work for the use of the students placed under his charge, and it is therefore well adapted to the wants of naval officers. Indeed, one cannot read it without feeling that he owes a personal debt of gratitude to Professor Cotterill for the fund of information and good sense which he conveys.

The work is divided into five parts: Statics of Structures, Kinematics of Machines, Dynamics of Machines, Stiffness and Strength of Materials, Transmission and Conversion of Energy by Fluids. These subjects are all treated by simple and clear methods, and the principles set forth are illustrated by numerous examples. In very many cases the problems are such as are of daily occurrence in the seafaring profession; and it seems fair to assert that, both with regard to the excellence of the methods used and the nature of the subject-matter, there is no recent book on mechanics so useful and valuable to naval officers as this one.

The Proceedings of the Royal Artillery Institution, for March, 1885, contains a very full description, with drawings, of an experimental hydraulic field carriage. When the nature of the service to which such carriages are subjected

is considered, this one appears somewhat complicated and elaborate in its details; but it serves to show the increasing demand for perfected apparatus in the handling of light guns even.

There is also an account of some practice with 9-inch M. L. R. mounted in a fort in the Isle of Wight, at ranges of 1600 to 2300 yards in firing at a moving object. The latter was an old boat, 20 feet long, with a triangular framework, surmounted by a flag erected on her; this target was towed in front of the battery at the distances already mentioned at a speed of about 5 miles an hour. Of 39 shots fired, 3 hit the target; and the mean point of impact of the 39 shots was situated 23 yards beyond the target and in the line drawn from the guns to the target. The range was found for each shot by a Watkins range-finder, the sliding leaf being set to allow for speed of target and effect of wind by the estimation of the officer in charge of the battery. The good judgment shown by the latter is apparent; since the lateral coordinate of the mean point of the impact is zero. The range finding seems to have been efficiently performed also; since, if the angle of fall was 3°—as was probably about the case—we find the mean point of impact to be situated in the *vertical* plane passing through the target at the middle of the boat's length and 1¼ yards *above* the water line. This is, unquestionably, about the proper adjustment of the mean point of impact in firing at such a target, for with the flat trajectories now ruling, a shot which passes some distance beyond the target, clears it by comparatively little, while shots which strike short, from the irregular ricochet of elongated projectiles, may be almost counted as lost.

There is also in this number a description of the objects of a Russian School of Gunnery recently established, and a statement of the rules governing it. The objects are stated to be: (1) the preparation of senior artillery officers for the duties of battery commanders; (2) to develop the instruction of gunnery in the artillery; (3) to spread through the artillery rational ideas with regard to the employment of fire in action; (4) to ensure uniform teaching with regard to gunners. The course at the school lasts one year, and certain officers are detailed, at stated intervals, to take it. The precise line of instruction adopted is very imperfectly indicated; but it appears to be of a practical, rather than theoretical nature.

As showing the extraordinary pitch to which the development of military science is being brought in Europe, it is interesting and curious to observe in some extracts from German newspapers which are given that the attempt is now being made to find how much labor the human frame can endure when put on short rations. Healthy, vigorous men are selected, and being confined to a strict campaigning diet, are marched for six hours a day in full marching order for a fortnight. They are weighed frequently, and many observations of their physical condition are made. The object of these experiments is two-fold: to find what the men can stand, and what food will best sustain them. No results are given.

Les Armées Étrangères en campagnes. Par A. Dally, Lieutenant Colonel Commandant de 98e regiment territorial d'infanterie, 1885. Paris: Print of the Typographical Society. A pamphlet of 106 pages with 80 illustrations, giving a general description of the armies of England, Germany, Austria, Russia, Italy, Spain and Switzerland, their organization, strength and how stationed. The illustrations show the uniforms, arms and accoutrements of the different corps and regiments.

BIBLIOGRAPHIC NOTES.

AMERICAN GEOGRAPHICAL SOCIETY BULLETIN.

No. 3, 1884. The life and scientific works of Arnold Guyot, by Professor William Libbey, Jr. A remarkable globe map of the sixteenth century, by A. E. Nordenskiold. Map. A trip from Söul to Peng-Yang, by J. B. Bernadou, U. S. Navy.

Ensign Bernadou, who has been for some time in Corea on special duty, gives us in this interesting article an insight into some of the customs and manufactures of the Coreans, as well as a description of the country as observed by him while travelling under escort from Sŏul, the capital, to Peng-Yang, the second city of importance in the Empire. The distance between the two cities is two hundred miles, and the journey was made on horseback. One of the cities visited by the writer, Song-To, the capital of Corea under the Ui dynasty until 1392, is especially mentioned, as to it many Corean families trace their origin—and in consequence of which the streets are lined with *pi* or stones commemorative of the terms of office of different officials, while other monuments of a similar nature are enclosed in gaudily painted buildings and are protected by a railing. Ensign Bernadou remained in Peng-Yang some ten days, and received no ill treatment from the inhabitants beyond a laugh at his appearance.

A journey from Cumberland Sound and on the west shore of Davis Strait in 1883 and 1884, by Dr. Franz Boas. Map.

Dr. Boas, a German explorer, surveyed Cumberland Sound and a large part of Davis Strait during a period extending from October 1883 to July 1884. He has corrected many inaccuracies existing on the English Admiralty Charts, founded upon former reconnoissances and upon the information obtained from English and Scotch whalers, besides adding new discoveries. The map accompanying the article indicates the extent of the survey and the corrections made. Dr. Boas' work was much impeded by reason of the dog disease which was particularly violent at Cumberland Sound in the fall of 1883, and by an epidemic of diphtheria among the Esquimaux being ascribed to his presence among them. The article contains a full account of the journeys made in prosecuting the survey, and a short summary of ethnographical observations made.

No. 4. Arctic Meeting at Chickering Hall, November 21, 1884, for the reception of Lieutenant A. W. Greely and his surviving companions.

A number of the Greely Relief Expedition and some prominent New Yorkers were present. Mr. Chief Justice Daly introduced Lieutenant Greely, who made an interesting address in conversational style, and received frequent applause. He stated that the expedition was not intended for exploration nor for reaching the North Pole, but its purpose was for simultaneous observations of the forces of nature in conjunction with the other meteorological stations proposed by the conventions of Berne and Hamburg on the original scheme of

Lieutenant Weyprecht. That the expedition was inadequately fitted out, "without proper funds, not having just those instruments that we should have." He made a handsome tribute to the work of Lieutenant Lockwood, who travelled 125 miles farther than his predecessor on the same route, and attained latitude 83° 24′ N., the highest yet reached by man. The geographical discoveries and the explorations of the several sledge parties were the chief topics, and no special reference was made to the legitimate work of the party at the Meteorological Station. In speaking of his men he remarked, "I am free to say that I think no better class of men ever went into the Arctic regions, taking them as a whole, than those who went with me. I testify here, publicly and cordially, to their courage, to their good temper and willingness to bear hardships."

He spoke pathetically of the good qualities of the dead, and concluded by expressing a hope that a suitable monument would be erected to their memory. Rev. Roswell D. Hitchcock, Prof. Theo. Dwight and General Egbert L. Viele made appropriate addresses, in which the effort to support Arctic Exploration was ably attempted. Nothing to show the commercial or scientific value of further exploration was stated, and the eloquent speakers dwelt on the indirect influences exerted, and the lessons of self-denial and suffering taught by the valorous deeds of the Greely Expedition.

Exploration of the Yukon River in 1883, by Lieutenant Frederick Schwatka, U. S. Army.

This article gives many interesting details of a raft journey of 1303 miles on the Yukon and notes on the topography and resources of the region. The most important statement is as follows: "Alaska has a grand future with its certain fisheries of seal, salmon and whales, paying us annually in them alone half its original cost of $7,000,000. The whaling ground is one of the most important ones left in the world, and paying yearly a million to our citizens; while salmon exist in her rivers in greater number than ever found in the Columbia, the present source of nearly all our supplies. Cod banks stretch along her coast that are so wide and long that they have never yet been outlined, and only feebly invaded as a commercial enterprise. Signs of precious metal are found everywhere, and her southeast islands would furnish ample timber supply for grand commercial cities; while those of the southwest would give grazing ground enough to supply the markets of a score of San Franciscos."

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

PART I, 1885. The indirect or approximate solutions for the two-altitude problem (continuation). Fernando Po, from report of German Corvette Möwe. Hydrographic investigations of the Nordenskjöld expedition to Greenland. Remarks upon Loma-Loma in the Viti Group. Description and sailing directions for the Paracel Islands in the China Sea. Report on the temperature coefficients of the 84 chronometers tested at Wilhelmshaven in the winter of 1883. The international conference at Washington, for the establishment of a common prime meridian and universal time.

PART II. The indirect or approximate solutions for the two-altitude problem (conclusion). Extracts from the voyage report of the German bark Jupiter. [These relate to Sydney and Newcastle, N. S. W., Manila and the straits of San Bernadino, Isabel harbor, Basilan Island, Sulu Archipelago.] Deep sea soundings in the N. Atlantic, between Cadiz and the Canary Islands. The weather tele-

graphy and the weather in Japan, 1883–1884. Two typhoons in Japan on the 15 and 17–18 September, 1884.

PART III. Supplement to the article on thunderstorms and hail-formation, by Dr. Andries. Remarks on several places on the West Coast of Africa between Loando and Cape Town, from report of the Möwe. Remarks on Cape Town, Cheribon, Java, thence to Soerabaya, and thence through the Bali straits, from voyage-report of bark Triton. New longitude determinations for the Australian observatory. Absolute determination of the horizontal intensity of the earth's magnetism at Wilhelmshaven. Practical rules for manœuvring in storms.

THE ARMY AND NAVY QUARTERLY. Philadelphia: L. R. Hammersley & Co.

VOL. I, NO. 2, APRIL, 1885. Modern cruisers. By Naval Constructor Theodore Albrecht, Austrian Imperial Navy. (Translated from the German, by Lieutenant W. H. Beehler, U. S. N.)

This is an excellent discussion of the reasons for and against the construction of this class of vessels, and of the steps made towards its development. The writer gives many of the details of some of the most approved and most recent specimens of this type. The recent action of the English Government in arming and attaching to their service a number of swift passenger steamers may have some influence upon this question in the future. The translator increases the value of the article by the addition of a list of the unarmored cruisers of the world, whose speed is fifteen knots or over.

BULLETIN DE LA RÉUNION DES OFFICIERS.

JANUARY 10, 1885. The Maxim Gun.

JANUARY 24, 1885. The voyage of the Jeannette.

In this notice of the book published by Mrs. Delong, appears the remarkable statement that the Jeannette expedition was the first American endeavor to reach the North Pole.

BOLETIN DEL CENTRO NAVAL.

JANUARY, 1885. Buenos Ayres. Scientific progress of the Argentine navy. Description of the English cruising torpedo boat Scout. Lectures on torpedoes and their employment. Continuous firing guns. Describes the Maxim automatic gun. Notes on the fauna and flora of the southern coast of the Argentine Republic (trans.). On some observations seldom employed at sea. State of the Argentine navy. Sounding machines, &c. (Plate). Mathematical investigation of the movements of an auto-mobile torpedo (trans.). Compulsory service. Movements of vessels and naval orders.

ENGINEER.

FEBRUARY 27, 1885. Conclusion of the Spezia plate trials.

Subsequent to the shots with the 100-ton gun, in November last, two shots were fired at each of the plates from a 10-inch gun, with the result that the

Brown and Cammell plates were completely broken up, while the Schneider plate, though badly cracked, withstood four shots. "The Schneider steel has, therefore, on this occasion won a remarkable victory. We could wish that the English plates had beaten it, but it is idle to ignore the fact that they were beaten."

ENGINEERING.

JANUARY 16, 1885. Steamboat equipment of war vessels, concluded January 23d.

JANUARY 23. The United States Navy.

An editorial note upon the annual report of the Secretary of the Navy for 1884, from which the following is taken: "We are not concerned just now to follow the report in the controversy that has arisen in America, and which has found an echo in this country, as regards the merits of the designs for the four new cruisers. Whether the Chicago will be a more efficient war vessel for having beam engines and brick furnaces, whether the Boston and Atlanta would be better with or without their 'peculiar features,' and whether they have too large or too small a sail area, can be more certainly discussed when the vessels have been launched and tried. It is no part of our duty to check a possible waste of American money on naval experiment."

The torpedo boat of the future.

According to the views of "Un Ancien Officier de Marine," the armor-clad ship is obsolete, and in any future war none would venture to sea until all the opposing torpedo-boats had been destroyed. The type proposed for a sea-going torpedo-boat is to be about 130 feet long and 12 feet beam, to be manned by 15 to 18 men, and to carry provisions for 12 to 15 days, and coal for 1500 to 2000 miles. She should be able to steam 22–25 miles an hour, and be armed with six or eight torpedoes and one machine gun. The cost would be about $70,000.

The United States Navy.

A letter written by "an American" in Paris, replying to some of the criticisms upon the action of the Advisory Board, in the editorial above noted. It is not perhaps generally known that one of the members of that Board who recently resigned from the service is living in Paris.

FEBRUARY 6. The autobiography of a Whitehead torpedo.

A serial purporting to give the adventures of a torpedo; in an entertaining manner a deal of interesting matter pertaining to torpedoes in general is given. The author is evidently well acquainted with ship routine.

American naval administration.

A further notice of the report of the Secretary of the Navy for 1884. "In England," the writer says, "we do not allow political considerations to govern the choice of workmen in dockyards. Our statesmen reserve such influence for muzzling the more august members of the naval administration."

Test for cotton seed oil.

Place about one teaspoonful of the oil to be tested in a wineglass, add an equal quantity of nitric acid, specific gravity 1.34, and place the glass in a basin of water kept at 60° F., add a small piece of copper about $\frac{1}{32}$ in. in diameter and $\frac{3}{8}$ in. long, and stir at frequent intervals. At the end of an hour, pure lard or olive oil will show white waxy flakes, and on standing for another hour the oil will have changed to a solid white mass. Pure cotton seed oil produces no flakes. Oils made from petroleum show black gummy flakes after twelve hours, but there is no other change, and mixtures give a soft pasty mass, according to

the nature and amounts of the adulterants. After a few trials with well known mixtures it is very easy to estimate very closely the characteristics of any oil examined.

Paulsen's Torpedo.

A self-propelling and steering twin-screw torpedo, the motive power being liquid carbonic acid. It is automatically steered by means of a compass, and upon any deviation from the course, the needle makes an electric circuit, decreasing the supply to one motor, and increasing it to the other, until the original course is resumed. An ingenious device prevents an alteration in the course when within the magnetic influence of an armor-clad. The shell is made of compressed water-proof paper pulp; a cable, detachable at will, may be used to render the weapon more effective. No official trials have been made.

FEBRUARY 20. Carbon in steel (concluded from February 6).

MARCH 6. Side armor *vs.* armored decks. The Nicaragua Canal project.

MARCH 13. The use of torpedoes in war.

FRANKLIN INSTITUTE JOURNAL.

MARCH, 1885. Tidal theory and tidal predictions. Report of the Board of Examiners, International Electrical Exhibition.

In this is a report concerning the Mangin projector and the McEvoy torpedo detector. The latter is a modification of the induction balance. It is enclosed in a sinker and dragged along the bottom, and if it comes in the proximity of a mass of magnetic metal like a torpedo case, the equilibrium is disturbed and a humming noise will be heard.

JOURNAL DU MATELOT.

NO. 9, 1885. The cost of English naval guns.

From a report of the English War Office, it appears that the cost of the B. L. rifles furnished by that department for use in the Royal Navy is about as follows: the 12-inch of 43 tons, $31,000; the 9-inch of 10 tons, and the 6-inch of 4 tons, $3,500. The 16-inch 80 ton M. L. R. cost $52,000 each.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOL. XIII, Nos. 1 and 2. The advantages and disposition of stations for towing ship-models. Special causes of lung diseases in the navy, and means of diminishing them. Modern cruisers. Experiments with the long 47 mm. Hotchkiss cannon. A quick method of deriving an approximately correct stability curve for one ship from the known stability data of another. Use of torpedoes on board the ships and boats of a war fleet. Rules for manœuvring in storms. Directions for putting electric lights in Russian powder factories, laboratories and magazines. Experiments in England with optical signals. Shipbuilding for the Danish Navy. The opening of a course of lectures on ship-building in the Glasgow University. Sketch of the fundamental conditions and formulæ for calculating the strength of new boiler plates (with tables).

REVIEW MARITIME ET COLONIALE.

JANUARY, 1885. Recent progress in naval ordnance. Historical account of the seaman-gunner. Apparent weight in ships at sea. The French cruiser Dubordieu.

Was launched at Cherbourg in December last, is of wood, 253 feet long, 46 feet beam, and draws 23 feet water. She will carry four 16 cm. guns in barbette towers, two firing forward and two astern, and twenty-two 14 cm. guns in battery, a number of revolving cannons and torpedo tubes on the upper deck. The engine is compound with three cylinders, and is calculated to drive her 14½ knots an hour. Ready for sea the Dubordieu will have cost in round numbers $753,000, divided as follows, construction, &c., $460,000, engine and machinery $153,000, armament $140,000. She is intended for service in foreign waters.

The laws of the perforation of wrought-iron plates (See page 329).

FEBRUARY. Investigations subsequent to shipwreck. Seaman-gunner (concluded). A new boat-lowering apparatus. Commander Fournier's law and its application to a cyclone in New Caledonia. Cryptography and its application to military art. The Farcy gun-boats.

These vessels, designed by M. Eugene Farcy for service in Tonquin, are of steel, 98 feet long and 13 feet beam, weighing about 30 tons each, and drawing two feet of water. The motive power is two paddle wheels, forward in channels which run the length of the vessel; the tiller is also forward. In the centre are the boiler, engine, and coal bunkers. Aft are the quarters for the crew of ten men, lockers for provisions and stores, the anchor, windlass, and a 3-inch gun.

MARCH, 1885. The Min River combats, by Captain Ch. Chataud-Arnault, French Navy. Farragut and Dupont, by E. Grasset, Inspector. The Protectorate of Tonquin, continuation from February No., by Captain A. Bouinais, infantry of the navy (Marine Corps). Cryptography, continuation from February No., by Captain H. Josse, French Artillery. Cholera epidemic of Guadeloupe (continued), by Walther, Surgeon-General French Navy. The Lay torpedo, late improvements, Williams torpedo. Removal of boiler crustation by electricity. Unequal distribution of heat in the two hemispheres, by Lieutenant G. Le Goarant de Tromelin, French Navy.

ROYAL UNITED SERVICE INSTITUTION JOURNAL, NO. CXXVII.

The papers in this number most interesting to naval officers are: "Machine Guns in the Field," by Captain Lord Charles Beresford, R. N., and "What are the Most Urgent Measures that Should be Taken for increasing Her Majesty's Navy?" by Sir Edward J. Reed, K. C. B., F. R. S., M. P. The discussion which follows the latter paper is especially instructive. Some of the remarks come home to us with great force at this time.

Hon. Wm. H. Smith, M. P., former First Lord of the Admiralty, says: "This should not be made a party question. We ought to insist that the conduct of the great services, the Army and Navy, should be altogether irrespective of the petty personal interests of gentlemen either on one side of the House of Commons or on the other. What we want is some system that will rise to the necessities of the case and see that the interests of the country are properly cared for."

Admiral Sir Spencer Robinson says: "Having once obtained the unanimous consent of the country that the navy is inadequate, do not dissipate that by anything like hypercriticism. I never knew a perfect ship, and never shall; therefore stick to one point, stick to this, that the state of the navy is insufficient."

UNITED SERVICE GAZETTE.

JANUARY 24, 1885. The Aquidaban.

This is the name of an armored turret ship, closely resembling the Riachuelo, built for Brazil by Samuda Brothers. The hull is of Siemens steel, with numerous compartments; sheathing of teak and metal extend to a height of two feet above the water-line to prevent fouling, while the stern (fitted with a ram) and the sternpost are of solid gun-metal castings. A water-line belt of steel-faced (Brown) armor seven feet deep and varying from seven to eleven inches thick protects the engines, boilers, and magazines, and the pumps for working the turrets; and an armor-deck two inches thick extends over the engine and boiler rooms, and is so constructed at the bow to strengthen the ram, and at the stern to protect the tiller and steam-steering gear. The engines of 4500 I. H. P. are expected to give a speed of 14½ knots with natural draught; the coal bunkers will hold 800 tons of coal—a quantity calculated to enable the vessel to make 6300 miles at 10 knots an hour. Provision is made by a middle line bulkhead for working the vessel, even if one engine or boiler room be flooded. The two turrets are placed in *échelon* and revolve within armored breastworks covering the loading gear; they and the breastworks and the conning tower on the bow are plated with 10-inch steel-faced armor. The Aquidaban will carry four 9-inch 20-ton Armstrong B. L. R. in the turrets, and four 5¼ in. B. L. Armstrong with Vavasseur mounting on the upper deck, two at the bow and two astern. There are five Whitehead torpedo ports, two on each side and one right aft; a second-class torpedo boat will be carried and fifteen Nordenfelt guns. Nineteen months were occupied in building the vessel, and in three months more she will be ready for sea, making twenty-two months in all, a noteworthy instance of the rapidity with which private English firms can construct such vessels. The Aquidaban is to be ship rigged with steel lower masts; dimensions are as follows: Length between perpendiculars, 280 feet; extreme breadth, 52 feet; draught of water, 18 feet; displacement, 5000 tons.

JANUARY 31. Gun experiments at Woolwich.

A 6-inch steel gun of the new pattern burst near the muzzle on board the Active, in November, 1884, during gun practice when fired with only 17 lbs. of powder, half the service charge. A committee, of which Vice-Admiral Luard was president, was appointed to investigate the cause. As the Active's gun could not have been double loaded, it was suggested that the explosion may have been caused by injudicious lacquering of the bore, or by the presence in the chamber of some foreign substance such as sand, cotton waste or old files. Iron and steel wedges of different sizes and shapes were therefore placed in a similar gun, and after firing, the effects upon the bore and shell were observed. The series of experiments have proved conclusively that the gun was not burst by an obstruction in the bore, and the gun will now be subjected to distortion by letting it fall from a height and by dropping heavy weights upon it, after which it will again be tested.

We have received a beautifully engraved map which has recently been published by the Hydrographic Office, Navy Department, Washington, D. C., of the Polar Regions from Baffins Bay to Lincoln Sea, this latter name having been given to the most northern waters. The map was made under the direction of Commander John R. Bartlett. It comprises the discoveries made

by the Polaris Expedition under Captain Hall, 1872; the British Expedition under Captain Nares, 1876, and the Lady Franklin Bay Expedition under Lieut. Greely in 1881–4. It was in this last expedition that latitude 83 deg. 24 min. was reached, being the highest yet reached by man. Captain Nares reached 83 deg. 20 min. 26 sec. Previously to these records came Captain Parry, in 1827, by way of Spitzbergen, 82 deg. 45 min. Reduced to miles, the Greely party exceeded Captain Nares, on reaching the North Pole, about four miles, and Captain Parry about forty-four miles. This is getting distances down to a pretty fine point.

NAVAL INSTITUTE PRIZE ESSAY, 1886.

A Prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1886. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the *Proceedings of the Institute*, and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the *Proceedings* of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *What changes in organization and drill are necessary to sail and fight most effectively our war-ships of the latest type?*

7. The Essay is limited to forty-eight printed pages of the "Proceedings of the Institute."

8. The successful competitor will be made a Life Member of the Institute.

9. In the event of the Prize being awarded to the winner of a previous year a gold clasp, suitably engraved, will be given in lieu of a gold medal.

[illegible] W. [illegible],
Secretary and Treasurer.

Annapolis, Md., *February* [illegible], 1885.